ORGANIC PHILOSOPHY;

OR,

MAN'S TRUE PLACE IN NATURE.

VOL. I.—EPICOSMOLOGY.

BY

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CONTENTS.—VOL. I.

INTRODUCTION.—MAN'S TRUE PLACE IN NATURE.

OUTLINES OF ORGANIC PHILOSOPHY.

OUTLINES OF EPICOSMOLOGY.

OUTLINES OF VERTEBRATE ORGANIC UNITY.

OUTLINES OF ARTICULATE ORGANIC UNITY.

OUTLINES OF CRYPTOGAMIC UNITY.

THE ATMOSPHERIC REALM.

THE PLUVIAL REALM.

THE OCEANIC REALM.

THE RELIQUIAL REALM.

THE GEOSPHERIC REALM.

THE ELEMENTAL REALM.

CONCLUSION.

MAN'S TRUE PLACE IN NATURE.

INTRODUCTION.—In order to know man's place in nature we must first know something of what man is, and also of what nature is. Man is not merely a skeleton, nor is external nature a congeries of bones. It is not possible, then, to find man's place in nature by placing the human skeleton at the head of a row of monkeys' skeletons. Linnæus and Cuvier have endeavoured to solve this problem on osteological and myological grounds of comparative anatomy; and these two leading men of science have arrived at different conclusions. Linnæus places man with monkeys in his "order of primates"; Cuvier makes one order of monkeys, or "quadrumana," and another of *homo*, or "bimana."

Where learned doctors differ, who shall decide? Some of the most eminent working naturalists plead for Linnæus, while others prefer Cuvier's view of natural distinction. We cannot hastily accept one view in preference to the other; but we may easily perceive that neither of these theories explains man's nature fully, nor do they give us a full view of epicosmic nature. How can we deal with this vexed question, when neither human nor external nature are explained to us?

There are in man a body and a soul, and both must be well understood before we can discover his true place. The human skeleton is but a fragment of the body; and though, to those who are well versed in comparative ana-

tomy, a part of any physical organism may shew the nature of the whole, still a fragment of the body gives no adequate idea of the living soul, which is the man.

Comparative anatomy is not enough to decide the question of man's place in nature; but even this has not been as completely studied as it should be. We must institute a new investigation of the laws of order in the human body, before we can be properly acquainted with the physical organism alone, not to mention the more important question of the soul. The laws of physical biology must be made more definite and simple, as a special branch of science, and those of mental biology as well, before we can know what human nature is; and when we have obtained this first degree of knowledge, we must then obtain as definite a view of the external world before we can decide the question of man's place in nature. What is integral man? What is integral nature? And what are the true relations of the one to the other? These are the questions to be answered by a philosophical inquiry. Before they can be answered properly we must discover a true organic method of investigation, a true organic science of man's nature and of universal nature, a true organic philosophy of life and organisation on our globe, a real insight into the organic laws of order in all epicosmic realms, and man's true place, at the head of all these realms.

It is a much more complicated question than has hitherto been dealt with. Nor can we, in a single volume, deal with all the aspects of this problem; but we may easily investigate the preliminary questions of physical biology and epicosmology, the simplest outlines of these sciences being sufficient to establish the laws of order, number, weight, and measure, which regulate all worlds, and give to man his natural place as the sub-creator of all arts and sciences, in obedience to necessary laws.

OUTLINES OF ORGANIC PHILOSOPHY.

ORGANIC PRINCIPLES AND METHOD.—The force of attraction by which a stone falls to the ground, is the same as that by which the moon tends towards the earth, and all the planets towards the sun. One law of gravitation rules all worlds. The simple fact of an apple falling from a tree is said to be the first occasion of calling the laborious and patient attention of Sir Isaac Newton to this class of natural phenomena, in which the smallest and the greatest facts obey one law. The heavenly bodies attract each other in direct proportion to their mass and to the inverse square of their respective distances. Such is the grand generalisation of the law which governs the simple fact of a stone falling to the ground.

The mathematical principles of natural philosophy have been thus extended from the simplest to the widest limits of the solar system. Is it possible to analyse and generalise the organic principles of physiological and psychological nature in like manner? Does the law which rules the life and structure of a simple organism also govern that of a whole class or realm of organisms? Does one organic law of equilibrium govern all the different realms of epicosmic nature? And further, do epicosmic and cosmic phenomena own one general law in the organic and the inorganic fields of observation? Are there organic principles of philosophy as well as mathematical principles? And if so, are the two one? And may we hope to find them illustrated in the simplest organisms of life as well as in the most stupendous systems of the universe? The hope may certainly be entertained from what we know of past experience in discovery, but many par-

tial failures may occur before complete success requites investigation. All truth is absolute, all nature's laws are perfect; but abstract mathematics have been hitherto applied to inorganic nature only, while they must exist, and may be found in living nature also. Sir John Herschel observes that "*number*, *weight*, and *measure*, are the foundations of all exact science." Are there any definite proportions of these factors in the organic as well as in the inorganic world? In the structure of elementary matter we find definite proportions of simple atoms and compound molecules regulated by laws of order, number, weight, and measure; and this discovery has made chemistry an exact science, as far as it is known at present. A similar discovery would render the organic sciences exact, as well as the inorganic sciences.

What are the simplest facts in which organic laws are manifest? To this question we may answer by another. What are the simplest facts in which some kind of structure is not manifest? And where do we see structure without law? The simplest elements of matter are not without form, although we cannot always analyse their ultimate constituents. Gold and silver, tin and lead, iron and copper, sulphur and mercury, are simple bodies of a different kind, in which the structure is most elementary, but little is yet known of the organic law exemplified in each.

Compound inorganic bodies are known to be more complex in what is called atomic union than simple elementary bodies; but little is yet known of the laws of complex inorganic structure. Organic substances are not less recondite in elementary build and conformation. It is not, perhaps, in the most simple facts of nature that laws of structure and of function are most easily observed, but in those which are most obviously complex. As the laws of cohesion and chemical affinity in matter were not as

readily observed and understood as those of gravitation, so the laws of elementary structure in matter may not be as easily detected as those of the more obvious forms and functions of inorganic and organic bodies. Elementary forms of structure, therefore, being more occult than those of complex individual forms, we may reasonably confine our attention to the one before we attempt to analyse the other.

From this point of view the general form and function, structure and development, of inorganic and organic bodies are the data of organic science and organic method, the exponents of organic laws of equilibrium in the realms of nature. An animal, a vegetable, or a mineral, are the simplest complex facts to be observed and analysed; a species, a family, a class, a realm of homœotypic organisms, are the most general facts to be arranged in parallel with those of a coordinate degree in nature. One law of order rules organic structure, possibly, in all these individual and collective bodies; but the highest organisms in each department will be most convenient for analysis, and thence we may take man as the highest animal, and one or other of the leading forms of vegetable and of mineral bodies as familiar examples. The latter may be left until we have a general idea of the human body as the highest form of a complex animal economy, our main object being to gain some insight into the nature of an individual organism before we deal with the more general questions of order and arrangement in collective bodies. We have to seek for the laws of *order, number, weight,* and *measure,* in the *forces, forms, motions,* and *modes of motion,* in the finite realms and bodies of the universe. Organic philosophy must be supported by organic science, and the latter must receive its definite form and structure from natural organic method, which is yet in embryo, and has to be developed as a positive branch of science. As

the author of the mathematical principles of natural philosophy had to invent the theory of fluxions to prove his laws of gravitation, so we must discover and explain the laws of organic method, before we can deal freely with organic science and philosophy. Comte says that transcendental analysis, as discovered and explained by Newton, Leibnitz, and Lagrange, is "the loftiest idea, the most admirable and powerful logical instrument, as yet constructed by the human mind"; but he afterwards describes his own historical method as a still more powerful instrument for the advancement of sociological science; and we must try to discover an instrument of natural organic method still more powerful than that of Comte.

The human mind may attain absolute precision in the evidence of method; positive certainty in the data of organic science; and the highest degrees of analogy and probability in the occult regions of philosophy.

Where science cannot penetrate directly, we must reason from the known to the unknown forces and phenomena of life, believing that one law of order rules all worlds, cosmic and epicosmic, natural and spiritual, macrocosmic and microcosmic, visible and invisible. Faith, then, in the principles of unity, as manifested in all known phenomena, affords a basis for philosophy in speculations with regard to supersensuous forces and invisible existence.

The main drift of organic philosophy is to obtain some knowledge of the laws of vital equilibrium in the universe, or the organic laws of order in the structure and economy of cosmic worlds, epicosmic realms, and hypercosmic forms and forces; as well as in the complex unity of any living organism or simple inorganic body.

Order includes the combination and cooperation of all the parts of a complex organism; number involves economy and fitness in the organic adjustment of parts per-

taining to one mechanism; WEIGHT and volume denote form, force, and motion, attraction and repulsion in all bodies, simple or complex, inorganic and organic; MEASURE includes rhythmic cycles of motion, form and function, in time and space; symmetry and proportion in bodies of all kinds, cosmic and epicosmic. Organic philosophy is, then, a definite thing; not a mystic verbalism.

What is the difference between philosophy and science? Science is positive, philosophy is speculative. Science is concerned with the facts and laws of known phenomena; philosophy, with those of unknown worlds and harmonies. What is the connective link between known and unknown facts and relations? Rational method, or the laws of order and degrees, in all known worlds of life and organisation, forms and forces, motions and modes, of motion. Organic method is the common basis of both science and philosophy.

It would seem logical, therefore, to commence the study of philosophy with that of method, and that indeed is indispensable for the original investigator; but it is one thing to investigate, and another to expose; as it is one thing to explore a new country, and another to construct a map intended to save future travellers the trouble of laborious exploration. Our present business is to give an illustration of organic method, as applied to both organic science and philosophy; the theory of method will naturally follow. Where the fruit is bad, the mode of culture is uninteresting; but where the fruit is good, the method of producing it is worth the effort of a little training. Let us taste the fruit, then, first; and leave the method of producing it for after-thought.

The "unity of science" has been deemed an ambiguous term, not properly defined, on any positive principle hitherto explained or understood; and therefore it has been condemned as "a vague effort of language to reach

an ambiguous truth;" but we may observe that the term has a very definite meaning as the representative of a legitimate hypothesis, which is all it claims to be, at present; while the meaning of a "vague effort" is very obscure; and "to reach an ambiguous truth," if we could guess what that might be, would hardly be worth the "effort." In spite of learned critics, then, we admit the hypothesis of a unitary law of nature, and the knowledge of this law would be a unitary science, which no "vague effort of language" alone would be able to reach.

It is curious to observe also, that the following remarks proceed from the same pen, as the one above, and in the same chapter; "that there is a design;—that it is not accident, or a blind necessity which evokes and maintains this world of life around us, need hardly be dwelt upon as matter of argument. The marks of law and mutual relation—of purposes fulfilled by organisation and instincts—are so indelibly impressed on the whole, that no seeming exceptions or anomalies can weigh for a moment against them, or leave a doubt as to the *unity of plan*, and its derivation from a higher source than physical science can reach. There is no neutrality on this question. To doubt is to cease to reason at all."

This is not a vague assertion, with regard to a unity of plan in nature, although the author, Sir Henry Holland, repudiates the idea of a unity of science with regard to this plan.

The author no doubt meant to say that the Rev. Baden Powel's philosophy of creation was a vague attempt to reach a very obscure and ambiguous definition of a truth which is beyond all human powers of comprehension.

None can suppose that life and organisation are independent of law in the world; and few would be reckless enough to suppose that there is anything but life and organisation in the universe. The conventional limitations

of physical science and philosophy may dwarf the individual mind, and render it unfit for other studies, but the human race will not be limited in its researches to the narrow boundaries of physical phenomena. Organic philosophy can only deal with life and organisation, but these include forces, forms, bodies, and motions of all kinds. Forces are not physical alone, but physical, moral, instinctual, and mental: forms are not alone organic, but inorganic also; motions are not only physical but mental; and modes of motion are not only various in matter, but also in what is called mind or spirit. Hence it is easy to perceive that physical science alone, can never give us the complete theory of universal science; and that physical philosophy can never be the true philosophy of life and organisation, however much it may agree with the subordinate laws of physical phenomena.

How shall we limit the field of our researches then? We cannot well begin with the study of forces and forms beyond the finite limitations of the orbs and orbits of our own solar system: the forms and forces of the sun, planets, moons, comets, and connective elements. The photosphere of the sun, the rings of Saturn, the *epicosmic realms* of each orb, and the comets which appear and disappear in turn, are the connective factors of the solar cosmos; and one of these alone, the epicosmic realms of our own globe, presents the most convenient field for primary investigation.

Physical philosophy deals mainly with inorganic phenomena; but these are not the only facts of epicosmic nature.

Organisation belongs to all bodies, inorganic and organic; the laws of order which belong to each may be the same in both, however much diversified in application. We believe they are the same, and hence we take the liberty of forming an hypothesis, which postulates the

truth of unity in universal law and universal science. Our efforts to establish a true philosophy on this hypothesis will not be the "vague efforts of language to reach an ambiguous truth," but a systematic analysis of all the epicosmic realms; and all the forces, forms, and motions of individual and collective bodies.

The human body is the highest type of physical life and organisation on our globe; the human mind, the highest type of mental forces and phenomena; and by the laws of order found in these, we shall attempt to gauge all other laws of equilibrium in nature. It may seem difficult to find one law for inorganic and organic realms, but the difficulty depends upon the method of investigation more than on the laws themselves. Let us, then, first look for an organic law in the human body, and apply this law to all other bodies, if we can. If this should fail, we can look elsewhere for a superior method. Organic philosophy must, however, comprehend the laws of all organic forms before it can deal with those of inorganic bodies: hence it is that we commence by the investigation of organic realms before we deal with inorganic nature.

Physical anatomy, histology, physiology, and embryology, may give us a key to psychological anatomy, histology, physiology, and embryology, and these together may include the highest laws of order in all worlds. Physical phenomena must be subordinate to these, if we admit that mind rules matter in creation, or that God by his eternal laws rules all phenomena in nature.

Should this hypothesis be questioned, then religion itself would be merely "a vague effort of language to reach an ambiguous truth;" and physical philosophy the only basis of eternal reason.

Forces, forms, motions, and *modes of motion*, are definite terms, easily distinguished from each other, although

we cannot separate them, or imagine them as separate in life. Force without substance is a mere abstraction; and form without substance is the same. Motion without substance is inconceivable; and modes of motion likewise. Modes of motion imply motion, then; motion implies substance; and substance implies force of some kind, without which it could not gravitate or move. Form and substance are not necessarily limited in our conception to the gross ideas we may form of matter as we see it on our globe, or even as we think of its tenuity in space; for substance may be really as subtle in its essence as the forces which we recognise in nature, while we own they are "imponderable," and even "immaterial," according to all common definitions of the word material.

Force and substance are eternal and indestructible, as we cannot even think of their annihilation; but forms and motions, inherent in all force and substance, are subject to mutations, and these motions and mutations to be orderly and consonant, must necessarily be subjected to laws of equilibrium, the natural basis of all truth and science.

We cannot speak of force of any kind without implying substance, form, and motion; but we need not limit substance to what is commonly termed matter. There may be other kinds of substance besides physical elements, as there are other kinds of forces besides physical forces. The body and the form of an angel may be just as real and substantial as the body and the form of a human being in this natural world, although the one is called a "spiritual body," and the other a "natural body;" but this is not a question for consideration here, as we are only on the threshold of philosophy.

We know that there are several kinds of force: physical, moral, instinctual, and mental forces; but we do not know that there are several kinds of substance, such

as physical, moral, mental, and instinctual substances, because we only think of visible and tangible reality. There may, nevertheless, be many kinds of essences invisible to natural eyes, imperceptible to our material senses; and it is quite illogical to circumscribe our limitations of ethereal substance, more than we restrict our definitions of imponderable forces; or to think that nature is less rich in the diversities of one, than of the other. All that we can truly say on this point is, that we do not know; and that amounts to nothing, either in science or philosophy.

Sails are as necessary to a ship as ballast; and however well the ship may be equipped and rigged, the captain requires a compass to guide him on the sea. Philosophy requires hypothesis as well as facts; and both require a method to verify the fitness of one to the other. Hypothesis alone is visionary; facts alone are barren; a natural method should unite the two to make them fruitful. Organic method must include both inorganic and organic nature; but the latter being most complex, is best adapted for the highest order of investigation. We first interrogate the organic, then, and afterwards the inorganic world.

Our hypothesis is this: that the law of life and organisation in man is the law of vital equilibrium in all worlds: one organic law of order in the combinations and permutations of forces, forms, motions, and modes of motion, in the living human body, and in all the living bodies of the universe. And by this we mean, that all bodies which are not dead are living; and that the so-called inorganic bodies may be either dead or living, as well as organic bodies: that all bodies, in fact, are endowed with some degree of force and life and organisation.

Organic philosophy has to deal with genetic metamor-

phosis in embryology; elementary cells and tissues in histology; complex organs in taxionomic anatomy; co-ordinate functions in physiology; and with each of these aspects of life and organisation in individual organisms, collective realms, and epicosmic unity. It has to deal with forms and forces, laws and principles, natural mutations of form and force in manifest existence; and also with the supersensuous or latent sources of forms and forces, from which all natural forces are derived in genesis, and by which they are absorbed in death or occultation.

What are *forms?* what are *forces?* what are *laws?* what are *principles?* what are *mutations* in the manifestations and occultations of life? These are some of the leading questions of philosophy.

All *forms* or types of structure are distinct facts in nature.

All *forces* are supersensuous, absolute, and indestructible: infinite in time, however finite or relative within the limits of form or space. The absolute in essence being infinite in time, is one in principle with the infinite in space and power. Limitations of the absolute in force, time, and space, are relative aspects of the infinite, and neither can be deemed "unknowable."

The word infinite, as here defined, only means that which transcends the finite and overrules it. It is a relative term with regard to finite limitations and degrees. The words absolute and eternal have a like definite meaning with regard to finite things. The word indefinite has no such meaning.

There can be no true definitions of the words infinite and absolute, but as transcendental factors in relation to the finite and the contingent.

The *principle* or doctrine of immortality is thus derived from the indestructibility of forces. Rational belief

in immortality is based upon this doctrine. Immortality of force and indestructibility of form are not, however, necessarily supposed to be convertible terms.

Laws of order are manifested in the genetic evolution, structure, and development of individual organisms and epicosmic realms, and may be traced in the structure and phenomena of cosmic orbs and systems. Laws are also absolute in truth and eternal in duration, as far as the mind of man can understand the transcendental with regard to finite limitations.

Mutations of life and force are manifest in the appearance of new organisms in this natural world at birth, and in their disappearance suddenly at death. Embryological phenomena bring latent forces from an unknown world, and necrological phenomena abstract these vital forces from the visible creation, either to absorb them in a latent form, or translate them to a world of occult or invisible existence. What is the absorption of manifest forces into an occult state? What is the evolution of forces from a latent to a manifest state? All forces, physical and psychical, are invisible or supersensuous. Are they alike in essence, or convertible in their various modes of manifestation?

The convertibility of physical forces is a fact well ascertained by science; the convertibility of psychical forces is not yet clearly ascertained. The evolution of physical forces from a latent to a patent state is partly understood; that of psychical forces from a latent to a manifest state, not at all. Evolutions and absorptions of all kinds of energy are witnessed daily, but the *modus operandi* is still obscure in most instances, or utterly unknown. Speculation has many things to deal with, then, where science is unable to penetrate. This will always be the case; for human knowledge must be limited; and however far the sciences may be extended, philosophy

will always have to lead the way in wider fields of exploration.

Do physical forces always underlie psychical forces, as the body underlies the soul? They seem to be distinct and separate from instinctual forces in the inorganic realms, but organic and instinctual faculties never appear separate from physical forces in the organic realms of life. All living bodies are accompanied by heat in some degree, with chemical affinities, cohesion, motion, gravitation, and other forms of physical manifestation.

The chick is hatched by means of heat; and during incubation the homogeneous matter of the egg, together with a portion of the inorganic substance of the shell, becomes transformed into organic tissues in the bones and muscles, nerves and viscera of the new organism, which manifests instinctual forces in connexion with organic form and physical energies. Is heat the source of all these occult forces, or merely the physical accompaniment of vital energy? It is evidently necessary to the manifestation of organic faculties, but it cannot well be deemed convertible with them, as it is often manifest apart in matter without life. Physical forces are indispensable for the manifestation of mental forces in the body; for when the organism is exhausted by fatigue, man cannot think with energy until the forces are restored by means of food and rest. This, however, merely proves that physical strength is spent by active thought as it is spent by active bodily exercise; but not that physical and psychical forces are correlative and convertible. Mental powers may never be absolutely independent of physical forces in one form or another, visible or invisible, and still be quite distinct in essence and in function.

Vital forces come into the body of the chick by means of heat as a physical condition; and when life quits the body of a pheasant shot in the field, the temperature fails

as occult life recedes from the active state of visible manifestation to the latent or transmuted state of invisible reality. It disappears, but cannot be annihilated. Whence we may conclude that all organic forces, instinctual, mental, and emotional, being necessarily supersensuous in essence, have an absolute existence in all states of being, visible or invisible, to us in this natural world. All forces being eternal, appear and disappear as they alternate from the sensuous to the supersensuous regions of phenomenal existence. The forces are occult in either case; but their activity is manifest to us habitually in the visible forms of life only, and exceptionally in communications from the supernatural world of forms and forces.

Here we find ourselves involved in the study of those "final causes" which have been so much disparaged by modern philosophers, from Bacon down to Comte inclusively. They have done good service in drawing attention to the great importance of direct observation and experiment; but without a teleological conception of final causes, inductive method is impuissant. It keeps us wandering amidst an endless maze, bewildering the mind more hopelessly as we multiply the number of small facts and physical phenomena. Delusive theories of reasoning from ideas without experience are now for ever gone, and we may acknowledge our obligations to those who have delivered us from such mistakes, without accepting their philosophy as final in its negative pretensions. "Theological and metaphysical" exaggerations are not more untrustworthy than "positive" or physical shortcomings; nor should we guard our reason less against the onesidedness of one imperfect system than another. "Theological, metaphysical, and positive" delusions are very much alike: just as the Negro said that "Cæsar and Pompey were very much alike, especially Pompey." Comte's posi-

tive philosophy, however, apart from its defects, is one of the best works of the present age.

Integrality is essential to all forms of truth; and as revelation is the basis of religion, so "final causes" are the basis of philosophy. We must not reject either one or the other of these true foundations on account of the defective superstructures which have hitherto been raised upon them. Superstition is not a necessary part of true religion. Delusive theories are not a necessary part of true philosophy.

Comte proposes absolute obliteration as a remedy for theological and metaphysical philosophy. We propose regeneration, and believe our remedy as positive. These definitions may be deemed imperfect by those who hold "devout reason" to be the true source of all religion, and observation the only basis of philosophy; but a comprehensive survey shews that a devout human conscience is the spiritual appetite alone, while revelation is the spiritual food of man, devout intelligence the mental appetite alone, while final causes, or eternal laws and forces, are the only satisfying source of knowledge for the human mind. The supernal fonts of knowledge and religion are external to human nature, the *capacities* for their reception are within; just as the sources of physical food are external to the body, while the appetite and the capacity for assimilation are within.

To satisfy these innate wants of body, soul, mind, and spirit, there is spiritual revelation from a supernatural world; and there are physical phenomena with final causes in the natural world, and these are easily found in universal nature and in man.

Space and Time are final conditions of life and organisation. Physical and mental occult forces embodied in matter are final causes of life and organisation. Motion and modes of motion are final causes or phenomena in

connexion with life and organisation. The laws of motion and organisation are also eternal causes. These may be defined as—

I. **The embodied forces, forms, and substances of life and organisation.**
II. **The regulative laws of life and organisation.**
III. **The final purposes of life and organisation.**
IV. **The supernal forces and conditions of life and organisation.**

The principient or supersensuous and indestructible forces of human nature are embodied in the sensuous or perceptible forms and substances manifested to us in this natural world by what are commonly called *body, soul, mind,* and *spirit.* The laws of equilibrium, which regulate all vital phenomena in human life and organisation, are those of *order, number, volume, weight,* and *measure.* The final purposes of human life and organisation are, *use, beauty, truth,* and *goodness.* USE in all industrial subcreations, BEAUTY in artistic subcreations, TRUTH in scientific subcreations, GOODNESS in social and religious organisations. The supernal forces and conditions of life and organisation are also of four kinds, *physical, instinctual, mental,* and *spiritual.* Without the physical substances and the perennial conditions of stability in our solar system, we could not have life and organisation in the body; without an instinctual source of renewed existence in the universe, all instinctual life would cease on this planet with the death of the present bodies of organic beings; without a mental source of power in the universe, all intellectual and scientific life would cease on this planet with the present generation of human beings; and without a supernatural world of spiritual forces, all moral and religious life would die out on this globe with the present individuals. In a word, without renewal from a higher source, all life and organisation in this world would become extinct at the death of all the present generations.

These, then, are final causes in human nature and in

universal nature. The study of these eternal causes is the natural business of organic philosophy. One of these, "the principle of the conditions of existence," is said to be "the true positive transformation of the doctrine of final causes, and of far superior scope and profit every way." Surely M. Comte must have been sadly blinded by prejudice against "theological and metaphysical" delusions, to lose sight of the great majority of final causes in adopting an obscure definition of one of them alone as a substitute for all. By the words "principle of the conditions of existence," we suppose M. Comte means the law of perennial stability in the conditions of existence; and that is not a sufficient definition of all final causes.

All forces are equally mysterious in essence. We cannot know their nature; but we can learn to estimate their results in phenomenal qualities and quantities, laws and combinations. Heat, light, magnetism, and gravitation, are not a whit less mysterious than instinctual and intellectual forces. Nor is it less delusive to build imperfect theories on physical forces and phenomena, than on metaphysical forces and phenomena. Theological, metaphysical, and physical theorists are equally exposed to error in forming their hypotheses; nor have they been less deluded by their fancies in past ages one than another. The Ptolemaic system of astronomy was a delusive theory of celestial mechanics based on a geometrical hypothesis of cycles and epicycles in the heavens. There have always been erroneous fancies with regard to all kinds of causes and phenomena in nature, and perhaps there always may be; but physical and mathematical philosophers have hitherto been just as liable to err in theory as theological and metaphysical philosophers. Nor are they less immersed in the study of final causes; for gravitation, heat, light, magnetism, and electricity, are absolutely indestructible forces quite incomprehensible in essence, and equally mys-

terious with instinctual, mental, and moral forces, as true final causes. All philosophy is, then, based on the laws of forces and phenomena; not on the incomprehensible cause of being.

It is, perhaps, hardly necessary to dwell on these self-evident facts; but the physical philosophers are so much opposed to the theories of metaphysical philosophers, that we are warranted in criticising their modes of reasoning as they criticise those of others. What can be more illogical than the following remarks of M. Comte in his chapter on human intervention in the sphere of physical phenomena, where he denies the power of divine intervention?

"As for the direct operation of this science (physics) on the human intellect," he says, "it is less marked than that of the two natural sciences which occupy the extremities of the scale,—astronomy and physiology,—which immediately contemplate the two great objects of human interest, the universe and man. But one striking fact with regard to physics is, that it has been the great battle-ground between the old theological and metaphysical spirit and the positive philosophy. In astronomy the positive philosophy took possession, and triumphed almost without opposition, except about the earth's motion; while in the domain of physics the contest has gone on for centuries,—a circumstance attributable to the imperfection of physical in comparison with astronomical science."

"With this science begins the exhibition of human power in modifying phenomena. In astronomy human intervention was out of the question: in physics it begins, and we shall see how it becomes more powerful as we descend the scale (of sciences). This power counterbalances that of exact prevision, which we have in astronomy, through its extreme simplicity. The one power or

the other—the power of foreseeing or of modifying—is necessary to our out-growth of theological philosophy. Our prevision disproves the notion that phenomena proceed from a supernatural will,—which is the same thing as calling it variable; and our ability to modify them shews that *the powers under which they proceed are subordinate to our own.*"

M. Comte must admit that the powers under which the physical phenomena proceed, and which are "subordinated to our own," must be, and are, subject to the same universal laws as those which govern the heavenly bodies in astronomy; and if man has the power to modify physical phenomena in accordance with these eternal laws, why should not God, as a "supernatural will" infinitely more enlightened than any human natural will, have a like power? We do not suppose that God ever suspends eternal laws, or that man can modify any natural laws; but if man can modify physical phenomena in accordance with eternal laws, surely we may suppose that God can modify physical phenomena, in accordance with these laws.

And again, with regard to the supposed absolute permanency of law and stability in astronomical phenomena, and the consequent "prevision of human science." What prevision was there with regard to "the comet of 1770, calculated by Lexel to have had then a revolution of less than six years, but has never appeared since, having been entirely deranged by passing too near Jupiter?" Is this prevision? Is not human science still imperfect in all its branches? and do not physical philosophers put forth imperfect theories as well as metaphysical philosophers? And is it because physical science has made more progress in our time than theological and metaphysical science, that the latter are to be placed in the *Index expurgatorium* of positive infallibility, as the physical theories

are placed in that of theological infallibility? Surely intolerant physical philosophy is quite as fallible as bigoted theological philosophy; and we may be on our guard against the exaggerated pretensions of both the one and the other.

What do we know of the laws of mechanical equilibrium in the universe, after all the discoveries of natural philosophy? What is known of the sidereal forces of light and heat, electricity and magnetism, as counter-forces to those of primary and secondary gravitation, in the physical equilibrium of nature? What is the nature of centrifugal forces as opposites of centripetal forces? Is not the vexed question of optical phenomena rendered insoluble between the two imperfect theories of emission and undulation? Was the problem of gravitation solved by any such secondary modes of speculation? Are not barren hypotheses as detrimental in physical science as in metaphysical speculation? Would not an emission theory and an undulatory theory of gravitation be as barren of result, as they have been in dealing with the laws of equilibrium in radiatory forces? Is not the law of repulsive force and distance between cosmic orbs in solar systems, as important as the law of concentration or attractive force and gravitation? And should not the cause of *volume* be studied as a counterpart to that of gravity in dealing with all problems of equilibrium in physical cohesion and celestial mechanics? And are not light and heat, electricity and magnetism, the forces which sustain form and volume in all bodies, great and small, in regulating intervals between all orbs and atoms, cosmic and epicosmic, inorganic and organic? And if so, what can the physical hypothesis of emission and undulation do for the solution of these important questions?

Molecular attraction and cosmic gravitation may be dissimilar in many points of parallel, and so may the

opposite forces of molecular distension, in epicosmic bodies, contrasted with those of orbital distension in solar systems; but, in either case, the forces of distension are opposed to those of concentration, and the relative forces of equilibrium must have relative laws of action and reaction, apart from secondary questions of elastic media, or hypothetical atomic motion.

We do not mention these defects of physical philosophy to undervalue the immortal labours of our scientific men; but toleration and impartiality are not less necessary in one school of earnest thought and speculation than another. Organic philosophy need not pretend to infallibility in our hands, but it must endeavour to be integral and impartial in all cases. We acknowledge the good services of theological, metaphysical, and physical philosophers in all past ages; and hope that all will help each other to improve by making new discoveries, and moulting worn-out theories and doctrines.

Organic method is the natural road to organic science, and as both precede the speculations of philosophy, we must deal with them as positive means of certainty before we deal extensively with questions of a speculative nature. Broad developments, however, are more easily perceived than minute or elaborate details, and hence we may survey the outlines of the former before we enter deeply into the investigation of the latter. A cosmic orb, a solar system, and a cosmic universe, are degrees of generality easily distinguished from each other; an epicosmic organism, such as the human body; an epicosmic realm, such as that of the vertebrata; and an epicosmic universe containing numerous organic and inorganic realms, such as those of our earth, exhibit also three degrees of unity and generality most easily contrasted with each other. The laws of order common to them all, are easily perceived when pointed out in their most

simple outlines. We will, therefore, make a rapid survey of these natural unities, before we enter into more elaborate details of method and organic science. And first, of the structural and functional laws of order in the individual organism of an animal or man.

Biology.—An individual being is a part of a collective unity of similar types, in cosmic and in epicosmic nature. In the epicosmic realms of our globe, the vertebrate type collectively and individually differs from all other forms of life and organisation; and as the vertebrata are the highest epicosmic forms, and humanity collectively the highest type of vertebrata, we may take man as the fittest subject for investigation in the study of biology; with a due regard to some peculiarities of structure manifest in lower animals, but not in man.

The ultimate atoms of humanity are twofold, male and female; each of these being integralities of an indivisible kind; but as one is only a contrasted aspect of the other, we may take one of them as our ultimate atom of integral unity, and state from this point of view that collective humanity is a constituent part of the epicosmic world; and individual man is an ultimate atom of humanity. This indivisible atom is nevertheless a very complex unit of vital forces and phenomena; a sacred unity of the creation, not to be desecrated by any kind of mutilation, in the order, number, weight, and measure of its constituent elements, organs, or faculties. And yet we wish to know it in its internal or constituent complexity. We cannot understand it well without an analytic and synthetic view of its integrity; but this can only be obtained approximately; for the organs are nothing in themselves, apart from their community of form and force in sacred living harmony.

The first artificial dissection of this biological unit gives us a fourfold aspect of its innate forms and forces,

more or less discrete in our conventional analysis; and these are commonly called *body, soul, mind,* and *spirit.* In the body we have a complex organism of physiorganic and industrial forces, faculties, or organs. In the soul, a complex organism of physiinstinctual and artistic forces and faculties; in the mind, a complex organism of physiomental and scientific forces and faculties; in the spirit, a complex organism of physiomoral and social passions and emotions. Not four unities, but one unity, in four different aspects of life; four partially discrete organisms in one atomic indivisible molecule or integrality.

These four organisms may be deemed respectively complete in themselves, for the convenience of further artificial dissection; and each of them may be analysed in a fourfold aspect, under the heads of *anatomy, physiology, histology,* and *embryology.* These terms have hitherto been applied to physical biology alone; but they are equally applicable to psychology. Our present purpose may be limited to the study of the body, leaving the mind for a distinct treatise on mental biology: and for the sake of brevity, we may restrict our first analysis to that of anatomy alone. This will give us one aspect of organic unity, from which we may derive assistance in the study of other views of human nature.

The Human Body.—What are the laws of order in the human body? What are the natural divisions of the organism into special systems and series of organs? There are seven distinct systems; neither more nor less; and five senses in connection with the seven systems. The cutaneous, the muscular, the osseous, and the nervous systems, form what is termed the animal or relational mechanism of the body, to which belong the senses of sight and hearing; the vascular, the digestive, and the generative systems, form what is called the vegetative or the organic mechanism of the body, to which belong the

special senses of smell and taste, and also a particular branch of what is commonly called the sense of touch. The seven systems, with their corelative five senses, and the different connective tissues and secretions which pervade the whole, may be thus arranged in a general synopsis.

Universal Connectives.	Z.	Supernal forces of the body.
	Y.	Ingesta of the body.
	X.	Secretions of the body.
	W.	Connective tissues of the body.

Organic Mechanism.	VII.	G.	VASCULAR SYSTEM.
	·7.	gg.	Vascular sense.
	VI.	F.	DIGESTIVE SYSTEM.
	·6.	ff.	Digestive sense.
	V.	E.	GENERATIVE SYSTEM.
	·5.	ee.	Generative sense.
Relational Mechanism.	IV.	D.	NERVOUS SYSTEM.
	III.	C.	OSSEOUS SYSTEM.
	2.	bc.	Osseomuscular sense.
	II.	B.	MUSCULAR SYSTEM.
	1.	ab.	Cuteo-muscular sense.
	I.	A.	CUTANEOUS SYSTEM.

Connective elements are not enumerated as special systems, because they intermingle with them all as dynamical and statical regulators of the organism.

In each system and connective class there are several distinct series of organs and tissues, which are thus distinguished :

UNIVERSAL CONNECTIVES.

Z. Supernal Forces.	H.	Uterine supplies of force.
	U.	Climatic forces of life.
	Ω.	Food stores of force.
	O.	Supersensuous forces of life.
Y. Ingesta; Impregna.	H.	Impregnata.
	U.	Infesta and investa.
	Ω.	Food ingested.
	O.	Blood in the body.
X. Secretions; Exuviæ.	H.	Parturitional out-births.
	U.	Glandular excretions.
	Ω.	Adipo-serous secretions.
	O.	Necrological exuviæ.
W. Connective Tissues.	H.	Fœtal amnion.
	U.	Glandular tissues.
	Ω.	Adipo-serous tissues.
	O.	Areolo-fibrous tissues.

ORGANIC MECHANISM OF THE BODY.

G. VASCULAR System.	H. *Umbilical series (in utero).* U. Respiratory series of organs. O. Circulatory apparatus or series. Ω. Urinatory apparatus or series.
gg. *Senses: (Inlets, Outlets.)*	H. *Capillary vessels.* U. Nose. O. Lymphatic vessels. Ω. Urethra.
F. DIGESTIVE System.	H. *Transitory forms (in utero).* U. Stomach. O. Small intestines. Ω. Large intestines.
ff. *Senses, etc.*	H. *Gland ducts of system.* U. Mouth and œsophagus. O. Duodenum. Ω. Anus and rectum.
E. GENERATIVE System.	H. *Wolffian bodies (in fœtus).* U. Ovaries. O. Uterus. Ω. Mammæ.
ee. *Senses, etc.*	H. *(Marsupium in kangaroos.)* U. Oviducts. O. Vagina. Ω. Nipples.

RELATIONAL MECHANISM OF THE BODY.

D. NERVOUS System.	H. *Vesicular grey substance.* U. Autocratic conductors. Ω. Autotelic conductors. O. Automatic conductors.
C. OSSEOUS System.	H. *Articulations.* U. Limb series of bones. Ω. Costo-facial series. O. Cranio-vertebral series.
bc. *Osseo-muscular Senses.*	H. *Sense of tension, fascia, etc.* U. Sense of hearing, ears. Ω. Sense of voice, glottis. O. Muscular sense, tendons.
B. MUSCULAR System.	H. *Cuteo-motor series.* U. Limb-motor series. Ω. Costo-motor series. O. Vertebro-motor series.
ab. *Cuteo-muscular Senses.*	H. *Mucous membranes.* U. Sense of sight, eyes. Ω. Sense of touch, palms. O. Sense of temperature.

A. CUTANEOUS System.	H. *Chorion in utero.*
	U. Limb series of skin.
	Ω. Frontal regions of skin.
	O. Dorsal regions of skin.

The letters used instead of numerals in these tables are merely symbols of distinction, and need not be explained until we treat of organic method. A few remarks on this point will be enough for the present. Individual organisms, the different systems in each organism, and the natural series in each system, require four sets of symbols to denote their special relations; and these we represent in the following manner. Individuals are either

Male	♂
Female	♀
Hermaphrodite . .	⚥
Neutral	θ
Diœcious . . .	♂♀

The seven systems and five senses in a single organism are represented by the letters A, B, C, D, E, F, G, or by the numerals 1, 2, 3, 4, 5, 6, 7; proceeding from the most external to the most internal systems, thus—skin, muscles, bones, nerves, generative system, digestive system, and vascular system; the four connective classes of tissue, etc., being represented by the letters W, X, Y, Z.

In the vascular system there are three regular and one transitory series,—the *respiratory*, the *circulatory*, and the *urinatory*, to which must be added the transitory umbilical series of vessels. These may be represented by the letters H, U, O, Ω, for *articular*, *superior*, *central*, and *inferior* series. In the relational systems the serial order is different; as in the osseous system, in which the vertebral, the costofacial, the limb series, are central, medial, and external; while the articular cartilages form a hyper-series coextensive with the other three, the symbols being Ω, O, U, H, or H, U, Ω, O.

This general view of the natural divisions of systems and series in the small universe of organs contained in an

individual type of vertebrate organism, need not be further analysed at present, as the order and the number of the parts here named are all that we shall notice in a general outline of methodical arrangement. The seven systems are easily recognised as natural distinctions, as well as their respective organs of sense; and the different series in each system are equally manifest to those who understand anatomy. The connective tissues and secretions are not less distinct, and the osculatory ingesta, etc., are easily recognised. "Supernal forces" may require elucidation to facilitate the understanding of the whole synopsis; and therefore we will analyse each of the four sections.

We call them *supernal forces* because life in the body depends on them entirely. The *supersensuous forces* are of four kinds, namely, physi-*organic*, physio-*instinctual*, physio-*mental*, and physio-*moral*, or *emotional*. These occult forces organise the body *in utero*, and animate it throughout life; disappearing at death, and leaving the abandoned frame to dissolution and decay. The symbols of these forces of the soul may be taken from the words we use for definitions, the first letters of which are, S, P, I, M, in Social or Spiritual, Physical, Instinctual, and Mental. We need not here inquire into the nature of these vital forces, but note that they are always accompanied by the supersensuous physical forces of heat, animal electricity, chemical affinity, cohesion, motion, etc., and that when the vital forces leave the body these physical forces also disappear. Without inquiring into the nature of the mental faculties, we may notice that the physical forces which sustain them in the body are constantly renewed by means of food derived from the external realms of nature; and that when these supplies of food are cut off, life is very soon extinct. We therefore class the realms of nature which supply the necessary food as *supernal forces*, without which the internal vital forces

rapidly cease to act. It is also known that food alone is not enough to secure the continuous action of the vital energics, and that with plentiful supplies of food the body may perish from cold alone, or otherwise suffer from defective climatic conditions; and hence we are obliged to recognise a climatic order of supernal forces. All these act *upon* and *in* the body during life, from birth to death; but there is also an order of supernal forces acting *on* and *in* the body, from the time of conception to the time of birth; and there are what we term uterine supplies of physical and organic forces in the mammalian class of vertebrata. In the oviparous class, the matter of the egg and the heat of the hen sitting on her eggs, supply the physical means necessary for the formation of the chick, while the organic and instinctual forces are at work in transforming these homogeneous elements into the flesh and blood, bones and nerves, of an animal organism. How the organic vital energies get into the egg, or whence they are derived, we need not now inquire; but without them the egg would remain a mass of unorganised matter, and no chick be hatched: hence the organising faculties are entitled to the rank of supernal forces. The uterine or incubational supplies of force, then, are of two orders, physical and hyperphysical, like those which are embodied in the organism throughout life. The hyperphysical forces in the vertebrate body are, organic, instinctual, mental, and emotional; the physical, supersensuous forces are those of heat, chemical affinity, etc. Degrees of power and evolution differ in the organisation of different types. The hyperphysical forces attain their highest development in man; but they are similar in nature, when differing in degree. The purely physical forces of organic life are greater in the higher animals than they are in man; and this is one main proof that physical and hyperphysical powers are neither identical nor convertible in principle

or in modes of action; for an elephant has much more physical power than man, while a mouse has very much less; and neither of them has proportional degrees of mental or of moral power compared with those of man.

These considerations show that the life of every creature once created depends upon external forces for its very existence, not only after it is born into the world, but even from the moment of its first conception, until the end of its natural career. The hyperphysical vital forces come from unknown sources, external to the egg in which the chick is hatched, and the physical vital forces are derived from heat and substance drawn from the external world, anterior to the organisation of the body in the egg. The natural life within the organism being dependent on external sources for existence, then, we term these overruling factors and supplies of force *supernal*, in relation to the organism which they uphold in life.

The systems and series of organs in the body, with their internal and external connectives and relations, give us a sufficient outline of human anatomy, or indeed of individual anatomy in every class of vertebrate organism, as far as taxionomic method and arrangement are concerned; and that is all we have to deal with in the present case.

Organic or Taxionomic Biology is the root of organic philosophy, and hence we must define what we understand by these terms, in contradistinction from unsystematic biology. By the word unsystematic, we mean simply analytical, as compared with the synthetical and living view of biological science. A brief analysis of taxionomic biology (*taxis*, order; *nomos*, law) will explain our meaning.

Organic Biology.	P. Physiorganic biology.
	I. Physio-instinctual biology.
	M. Physio-mental biology.
	S. Physio-spiritual biology.

At present, we shall deal with the first of these divisions only, and contrast it with the ordinary branches of anatomy and physiology, which are purely analytical in principle and method. These are :

1. Comparative anatomy and physiology.
2. Descriptive anatomy and physiology.
3. Regional anatomy and physiology.
4. Histological anatomy and physiology.
5. Minute cell anatomy and physiology.
6. Chemical anatomy and physiology.
7. Embryological anatomy and physiology.

Each of these is multiplied by three divisions or aspects of the question : namely, those of normal, abnormal, and morbid anatomy and physiology.

To these we may add palæontological anatomy and physiology ; and all these branches of science are purely analytical and unsystematic. They do not rise to a taxionomic or synthetic view of physiorganic biology. The differences here noticed will be more easily understood by the general reader, if we state that carpenters, masons, glaziers, smiths, and other persons connected with building, are not architects ; and that they may be well acquainted with their respective branches of the building trade without much real knowledge of the science of architecture. The same may be said of anatomists and physiologists : they may have a very good knowledge of one or all of the above branches of the science, and still be ignorant of the laws of *order* and *degrees* in the natural structure and functions of an organic universe. We suppose the reader to be more or less acquainted with the analytical branches of anatomy and physiology, before he undertakes a critical investigation of synthetical biology. If not, he has to take for granted all we say of these, in our methodical arrangement. The same distinctions will apply to our instinctual, mental and emotional biology.

Philosophy is also analytical or synthetical in the same sense as biology. The universe is analysed as a cosmic organism of physical forces only, or it may be studied as an organism endowed with supersensuous forces to control the motions and mutations of its physical forces, as the mind of man controls his body, or the instinctual forces of an animal control its motions and associations.

MATERIALISM, as a philosophy, is purely physiorganic; THEISM, as commonly understood, is partially organic. According to this view, God rules men and angels as living beings, in the natural and supernatural worlds, and manages the cosmic orbs, as locomotives or electromechanical automata. ORGANIC PHILOSOPHY deals with occult physical and hyperphysical forces in human, epicosmic, and cosmic nature. In this philosophy, animals and men, planets and suns, are animated by supersensuous, physical, and hyperphysical forces, and governed alike by one Almighty ruler and creator.

This conception is not new, for it has always been held by a few persons in all ages. It may or may not be true of a cosmic system, but it must be true of an epicosmic universe; and that is the most interesting question for us, at present. We mention it, more to show the drift of our speculations, than to inculcate a doctrine which is merely hypothetical. Organic cosmology may be very uninteresting, but organic anatomy and physiology are essential to a proper comprehension of biology and sociology.

Organic cosmology does not involve a special theory of hyperphysical forces in cosmic orbs; it merely implies the necessity of order and degrees in the structure and functions of cosmic bodies: the laws of order being the same, whether a cosmic orb be constructed as a locomotive, or an automaton; as a vegetable organism, or as an

animal of low or high degree; or as a being of much higher faculties and powers than men or angels of the epicosmic order of creation. Trees, animals, and men, have living hyperphysical forces, animating matter, and ruling occult physical forces in the body, but they are not independent of God and His controlling Providence. Cosmic orbs may have any amount of one or all of these hyperphysical forces, in addition to the matter and the supersensuous physical forces they possess, and yet be very finite creatures, subject to the same control as vegetables, animals, or men. From experience we know of the existence of hyperphysical energies in addition to occult physical forces in plants, animals, and men, but only judge by implication of the possible gradation of such forces in higher beings, progressively rising from men to "angels, archangels, principalities, powers," etc., etc., up to the idea of supernal unity in God. And here we may observe that there is logical inconsistency in supposing that the cosmic universe is subject to mechanical laws and forces alone, while the major part of our epicosmic universe is subject to the much higher order of biological laws and forces in vital equilibrium.

The perennial existence of the land, the sea, and the atmosphere, as distinct realms on the surface of our globe, is perfect evidence of the existence of hyperphysical forces of at least the lowest organic degree, in the constitution of our planet; for these organic forces are sufficient to maintain the distinct structure of each of these realms, in the midst of the perpetual action of supersensuous physical forces, such as heat, light, electricity, magnetism, chemical affinity, cohesion, motion, and gravitation, in one and all, alike; just as the organic hyperphysical forces of a tree control the play of all these occult physical forces in the formation of wood and bark, leaves and flowers, fruit and seed. "The ability to repair

the damages sustained by injury" is not an exclusive property of living beings; for even crystals will repair themselves when, after pieces have been broken from them, they are placed in the same conditions in which they were first formed. There is a law of structure, then, in what are called the inorganic forms of matter; and occult forces conform to law in these realms as in the hyperphysical organic realms. These are speculations, however, which may be pursued more fitly, after some acquaintance with organic method and organic science; and therefore we leave them for the present. That there are laws of order and arrangement in the structure of the universe we cannot doubt; that these laws rule each solar system, and each cosmic orb, we may be sure; that similar, if not the same organic laws, may be found in the inferior realms of nature, seems quite possible; and not improbably one law of order governs universal nature. We must, however, first examine natural objects under a few simple aspects before we complicate the study with elaborate details. An animal, a vegetable, or a mineral body, presents some general features which are easily observed, and these we notice first, to obtain a ground for more minute investigation.

In the human body we have noticed seven distinct systems accompanied by five orders of peculiar sensuous organs, with four classes of connective elements and forces: and these we have arranged in what may be termed the chromatic order of progression in harmonic fractions: the serial subdivisions being arranged in consonant order. They may as readily be classed in simple diatonic order. Here, again, we speak of method before the proper time; but merely to forestall objections which might question the propriety of such a distribution. Before we can explain natural organic method, we must apply it to natural organic science, as a test of its

utility; and therefore we deal with the natural sciences before we treat of abstract method.

Harmonic fractions, in the animal economy, relate to such divisions of the organism as are complete and natural, without any kind of mutilation in the special organs, series, systems, and connective elements. Irregular divisions exhibit the fractions of the body in a disconnected form, and thence they may be termed unnatural and arbitrary. There is a scale of sounds in a musical octave, and these may be divided either properly or improperly, for musical purposes: the natural division of the scale is harmonic; while an irregular division would be discordant and unnatural. To give the general reader an idea of what is understood by the words "harmonic fractions," as applied to the division of the human body into systems and series, we may state that, as vulgar fractions denote any kind of fractions in the parts of an integer in mathematics, while harmonic fractions denote only such numerical divisions of vibrations in a musical scale as are musical, so in the carving or dissecting of a fowl, or any other animal body, vulgar fractions denote such divisions as are most convenient for serving the guests at table, while harmonic fractions denote such dissections only as separate the organs which have special and distinct functions. In carving a fowl you separate a wing, for instance, and in that you find portions of skin, muscle, bone, and nerve, not to mention bloodvessels and connective tissues. In dissecting a bird for scientific purposes, you do not cut it up in vulgar fractions, but you carefully separate the whole skin from the muscles, these again from the bones, the nerves from all the other organs, and so of every set of organs in the body. By this method we find seven systems and five senses in the integral organism, neither more nor less; just as we find seven diatonic notes and five intermediate notes in the

complete musical scale. Hitherto the human body has been dissected by anatomists without a due regard to this natural law of number in harmonic fractions; and although the vascular system was the only one in which the natural unity had been neglected, this oversight caused its three divisions to be added to the other six, and thus the number nine instead of seven appeared to be the primary number of distinct systems in the animal economy.

The same want of knowledge on this point has caused zoologists to carve the organic realms of nature on a plan of arbitrary vulgar fractions in lieu of natural harmonic sections.

Harmonic numbers and notation in all realms will form a special chapter of organic method. Meanwhile we may observe that lower types of animal organism contain a twofold mechanism like that of vertebrata, with some disparity of form, number, order, and distribution. An articulate animal, such as a crab, contains a vascular, a digestive, and a generative system, with appropriate organs of sense adapted to each, in its organic mechanism; and also, a nervous, a muscular, a cutaneous, or a complex cuteo-crustaceous system for the support of its muscular system, in addition to special organs of sight and hearing. Connective glands and tissues are also manifest in this lower type of organism. In the mollusc we find vascular, digestive, and generative systems, with their special organs of sensation; and also a muscular, a nervous, a cutaneous, and a sort of osseous system, with organs of sight and hearing in the higher types, such as the cephalopods. And here again connective tissues and secretions are essential to the special systems of the organism. In lower types of animals, such as the starfish and other echinoderms, we find a vascular, a digestive, and a generative system in a less developed state, as well as a nervous, a muscular, and a cutaneous system. In the highest

vegetable organisms, a lower kind of vascular, digestive, and generative organs are manifest, while something like a corresponding fact to the relational mechanism of the animal type may be noted in the wood, the pith, and the bark of a large tree or shrub. Nor are connective elements less evident in the gummy secretions, and the cellular tissues of a tree, than in the corresponding parts of an animal. In the lowest types of vegetable structure, functions similar to those of digestion, absorption, circulation, and generation to perpetuate the species, are performed by the simple organs of the cryptogamic plant.

In minerals, the structure is apparently more simple, and cannot easily be placed in parallel with that of organic bodies; but a corresponding view of functions will bring them into nearer relations when we come to treat of characteristics, in another part of our inquiry. At present we may dwell more profitably on the leading principles of structure in the human body, as a complex type of order and arrangement; and try if we can find a similar law of order in the distribution and economy of a more general unit, such as that of a collective realm of the same type. The realm of vertebrata is distinct from other realmic types, and if the laws of order be the same in every complex unit of life and organisation, we may expect to find them manifested in collective and in single organisms alike; with only such diversity of illustration as the natural modulations of variety in unity call forth. To ascertain man's place in nature, we must analyse the realms of epicosmic unity to which humanity belongs; and the natural relation of these realms to human industry will give us a solution of the question. Let us see, then, what the natural arrangement of an epicosmic unity may be, compared with that of the human body; and the natural order of a complex realm, compared with that of an individual organism.

Before we deal with a collective realm, which may be subdivided in various ways by different methods, we will analyse the epicosmic world, which cannot be so easily distorted by mere fanciful arrangements. Observing that, in this analysis, we shall dwell mostly on the laws of organic order and number; leaving those of weight and measure for more elaborate consideration in other volumes.

OUTLINES OF EPICOSMOLOGY.

1. Kosmos and Epicosmos.—The globe itself, being more or less distinct from all that we can see and analyse upon its surface, the cosmic orb is easily distinguished from the epicosmic realms. The kosmos is controlled by God alone; the epicosmos is in part submitted to the care of man. His duty therefore is, to understand the world in which he lives, that he may govern in obedience to perfect law.

Is there a perfect law? and if there be, can man discover it? We must believe that harmony exists in all the works of the Creator, and that the laws of order may be seen in the phenomena of nature.

Is there an architect of nature? a plan of order in organic structure and genetic evolution or development on our globe? Is man himself a microsmic universe constructed on the same principles of order as those which rule the macrocosmic universe? Intuitive belief may answer all these questions without hesitation, or prefer to wait for such response as analytical investigation may supply. Intuitive belief is satisfactory to some extent, but science can alone give power in support of such belief.

Epicosmic science, as a unitary definition of organic law and order in the world, does not exist at present; the very name is unfamiliar. A certain knowledge of

some of the laws of natural phenomena in the "animal, the vegetable, and the mineral kingdoms" has been acquired, but man's relation to the realms of nature, and his progressive mission as the secondary ruler of the epicosmos, are not well understood; much remains to be accomplished before such a science can be formed. It is but recently that men have thought of inquiring seriously into the question of man's influence on external nature, and the influence of external nature on the destiny of human nationalities and races. Philosophical historians in different parts of Europe, have thrown much light upon these facts, and their continuous researches will, no doubt, assist in opening new channels of investigation; but organic science and organic method are still unconscious of the final end they have in view, and seem content to labour in the fields of fragmentary knowledge, without a lively hope that anything of a much higher scope than special sciences, can ever be attained by man. And yet the questions above stated are becoming urgent, as one discovery succeeds another in the rapid evolution of new sciences. There seems to be a want of confidence in looking at so high an order of generalisation, and a want of method to grapple with the subject. There are, no doubt, many questions to be answered, and much time may be required to find true answers; but that is no sufficient reason for neglecting them.

Can inductive method answer any of these questions, or must we have recourse to a deductive method, to marshal in order the multifarious cumulations of inductive science? Without a teleological conception to give life and purpose to creation, the natural sciences, built up in fragments by inductive method, have no real meaning for the human mind, which looks upon their various results and disconnected aims as a child might look upon the scattered wheels and levers of a watch, or a chro-

nometer, and wonder why they had been made, or whether they belonged to one or many systems of machinery. But how can we obtain an insight into the laws of epicosmic unity? This, no doubt, may be a very difficult operation; but a careful study of some one part of the creation may lead to the discovery of laws which rule in other parts; and man himself affords us an example of a complex universe of organs differing in form and structure, local adaptation and especial function, in accordance with a higher plan of unitary form and function, in which, obedient to a common law, they all unite and harmonise. This multiplicity of organs in a smaller universe may be arranged in order, on the very same principle as that which regulates the natural order and arrangement of phenomena in a larger universe; and thus the plan of epicosmic unity may be revealed to us in human nature. It may be so; but is it so? that is the question.

A comprehensive view of natural order in the human body, gives us a teleological conception of the laws of natural order in the epicosmic universe to which the human organism belongs; and this may form a basis for deductive method to complete the necessary operations of inductive science. Organic method, to be perfect, must include both systems of investigation, and the manifest shortcomings of the one now claim assistance from the other. We shall therefore attempt to give an outline of epicosmic unity from a *deductive* point of view, according to the laws of natural organic method, as displayed in human nature.

Hitherto, three "kingdoms" only have been recognised on our globe: "the animal, vegetable, and mineral kingdoms;" and these have been variously subdivided into "sub-kingdoms," without a natural principle of order and connective union. We must follow a somewhat dif-

ferent method to arrive at a more satisfactory result. We shall not disturb the natural divisions, but add to them, where such addition is required, and modify, where change is necessary. A dozen distinct realms cannot be well classed as three kingdoms, and the natural subdivisions of these realms are not always coincident with what are commonly called "sub-kingdoms."

Cuvier has defined four great plans of animal organism in zoology; Linnæus, two main types of vegetable structure in botany; and these are the most distinct organic forms in epicosmic nature: namely, *vertebrata, articulata, mollusca, radiata, phanerogamia,* and *cryptogamia.* They have hitherto been called "sub-kingdoms," but they are evidently distinct realms, in contrast with the inorganic realms of our globe. These are also six in number, when properly defined: namely, the *atmospheric, oceanic, geospheric, pluvial, reliquial,* and *elemental.* There are, then, a dozen realms, in the so-called "animal, vegetable, and mineral kingdoms."

These realms are neither "continuous" nor "dichotomous" in their connection: the atmosphere is not a continuation of the sea; the sea is not an "embranchment" of the land. Organic realms are equally distinct and parallel in distributive order. There is no common stem or type in which the different sub-kingdoms meet, and therefore the term "embranchment" used by Cuvier is inapplicable. The skin is not an embranchment of the muscles in the human body, nor are the muscles an embranchment of the bones.

The number twelve is, then, a natural primary division of the realms of our globe and of the systems of the human body; representing fulness and completeness in the one as in the other. In the body we have a complex universe of organs, and these are distributed in seven or twelve parallel systems. The teleological parallel be-

tween these systems of a complex microcosmic unity and the realms of an epicosmic universe, is not, perhaps, self-evident; nor do we mean to dwell upon it here, further than to intimate that such a correlation does exist, as far as parallels of order, number, and degree are concerned, in the principles of method. The skin, the muscles, the bones, and the nerves are more or less parallel and concentric in the body. The vascular, digestive, and generative systems are not concentric, but they are parallel in all their subdivisions; and the same may be said of the five senses, coordinate with the seven systems. A complete synopsis of the epicosmic realms gives us similar parallel divisions: thus,—

Inorganic Realms.		*Organic Realms.*	
A.	ATMOSPHERIC REALM.	ee.	Cryptogamic realm.
a, b.	Pluvial realm.	E.	PHANEROGAMIC REALM.
B.	THALATTOSPHERIC REALM.	ff.	Radiata realm.
b, c.	Reliquial realm.	F.	MOLLUSCA REALM.
C.	GEOSPHERIC REALM.	gg.	Articulata realm.
D.	ELEMENTAL REALM.	G.	VERTEBRATA REALM.

The number and order of these realms run parallel with those of the different systems in the human body, and the natural orders of mammalia in the vertebrate realm; suggesting at once the idea of teleological unity in the plan of nature.

In using the word teleology, we do not mean the doctrine of *ends* and *uses* alone, but also the doctrine of *means* and *principles*. An *architect* of nature, a *plan* of creation; a *law* of life and an *object* of life, are all included in the word teleology, or the doctrine of final causes. "Unity of composition" is manifest in the plan of creation. A partial knowledge of these laws and principles, however, is all that we can hope for in this natural world. Secondary causes and effects are probably all that we can ever know or understand; and even

these within but narrow limitations. We have now to seek for what is common, as a law of order, in all realms; and also for the primary relations between the inorganic and organic worlds. Their dependency is evidently mutual, as the inorganic furnishes support and sustenance to the organic; while the latter, in their turn, improve the structure of the crust of the earth; many rocks being mainly formed of fossil shells and the remains of extinct animal and vegetable organisms.

The subdivisions of each realm into classes, sub-classes, orders, and families, have not hitherto been made on any common principle of method; but we may venture to suggest that such a principle exists in nature, and proceed to give an outline of the facts.

In the realm of vertebrata the most obvious primary distinctions are those of the four classes,—fishes, reptiles, birds, and mammals. And here we remark that three of these classes are almost entirely oviparous, and only one viviparous. Some of the oviparous types being ovoviviparous, does not make them placental or mammalian. One main class, then, and three inferior classes are easily recognised in this realm. Does the same law of subdivision hold in all or any of the other realms?

But first we may observe that some zoologists have given the name of class to the sub-classes of reptiles and fishes, such as batrachia, etc., established by Cuvier; and this we deem a cause of confusion, for it is important in this and other realms not to confound the natural distinctions of classes with those of sub-classes.

In the realm of mollusca numerous classes have been formed by different zoologists; and it may seem captious to question the propriety of names when the distinctions are legitimate, but confusion in the use of terms leads to obscurity in scientific definitions, and that should be avoided. We agree with De Blainville, that cephalo-

phorous molluscs form only one main class, in contrast with three inferior classes of acephalous or headless molluscs. Gasteropods, pteropods, and cephalopods, are therefore sub-classes only of one great class of cephalophora.

Univalves and *bivalves* would be simpler and more graphic distinctions between the primary class and the secondary classes of molluscs; but then there are many tribes in both the cephalophorous and the acephalous divisions which have no shells at all.

In the articulate realm crustacea and arachnida form subdivisions only of one main class, and other so-called classes in the secondary ranks of this realm are only entitled to subordinate distinctions. Insects alone form a natural and complete secondary class in the usual arrangements.

In the realm of radiata various divisions into "sub-kingdoms," classes, and sub-classes, have been established by eminent zoologists; and here again we must acknowledge that one main class of vermiform echinoderms, and three secondary classes of radiata or "zoophytes," answer all the purposes of primary natural distinction. The most recently adopted names for the secondary classes of this realm are probably the best, and the natural distinctions will suffer no violence in changing the name of "sub-kingdoms" for that of class. We shall therefore call *protozoa, celenterata, echinodermata,* secondary classes of the radiata; the main class being thus restricted to the vermiform radiata, such as holothuria, synapta, etc. This is not in accordance with the usual arrangement, in which holothuria are deemed inferior types compared with echinus; but we have no doubt of the superiority in structure of synapta and other tubulous radiata compared with the spheroïdal and asteroïdal echinoderms. The vermiform radiata are still too little known or studied to settle the question finally; but De Blainville's views have convinced

us of the superiority here claimed for the vermiform class, as the nearest approximation to the next higher realm of organic type and structure.

The phanerogamic realm of vegetable organisms contains one main class and three inferior ones, one dicotyledonous class of "exogens," and three monocotyledonous classes of "endogens." All botanists agree in placing exogens as a superior class; but some difference exists in the arrangement of endogens. The most natural primary subdivision seems to be that of Ad. de Jussieu, who recognises three secondary classes, which he defines as *aquatic* endogens, *aperianthous* endogens, and *perianthous* endogens.

The cryptogamic realm has been naturally divided into one superior and three inferior groups. The main class is that of "*acrogens*," the secondary classes being "*thallogens*." The latter have been well named *algales, fungales,* and *lichenales.* Hence we see in the organic realms a common principle of distinction between primary and secondary classes. The first stands as *one* to *three* of the latter: just as the main tissues of the human body stand to the inferior connective tissues of the organism. Lindley forms two classes only of cryptogamic plants,--acrogens and thallogens; but that is as imperfect a view of their natural relations as the distinctions between viviparous and oviparous vertebrata would be if classed as equal divisions.

Let us now examine the inorganic realms, which are no doubt subject to laws of elemental structure, and consequently to organic laws, although commonly called "inorganic." These inanimate realms, so intimately blended with superior cosmic nature, must conform to law; and, not improbably, all secondary laws are subject to one universal principle of order and association. A crystal is a distinct body with a given form and some peculiar

characteristic modes of action and reaction. A drop of water is also a distinct embodiment of a peculiar elemental structure, and the same may be affirmed of air and other gaseous substances. Individual structure, therefore, is manifest in the embodiments of inorganic realms; and general distinctions must be as natural in these as in organic realms. This fact has been already recognised to some extent by those who cultivate the science of the inorganic world. The individual complex unity, however, in these realms is much less obvious than the collective complex unity; and therefore we shall first deal with the latter only.

Geologists have recognised four distinct classes of rock-formation *in the geospheric realm*, namely the "*aqueous*," the "*metamorphic*," the "*plutonic*," and the "*volcanic*." These distinctions are natural, but not as accurate as a methodical analysis requires; for the aqueous formations belong mainly to the reliquial realm, while the igneous or hypogene rocks being strictly homogeneous in form and character, belong to one natural division of the inorganic world. Here, then, we have only three recognised classes of rocks, instead of four, and one of these, being in a constant state of active or volcanic operation, as compared with the other two, may be placed in parallel with the primary class of other realms, while the other two, the metamorphic and plutonic, being relatively more quiescent, may be deemed of secondary rank.

A third inferior kind of rocks would be required to form a parallel of three secondary classes and one primary class in this as in the other epicosmic realms, but no such class has hitherto been recognised; and we must venture to suggest that the peculiar character of the magnetic polar strata, which have not been thoroughly investigated, may possibly be entitled to rank as a distinct secondary class of hypogene formation.

Thermoelectric action is no doubt a very important function in all hypogene rocks, and polar magnetism is a very distinct class of electro-magnetic phenomena. Heat and moisture are manifest agents in all geospheric evolutions, and especially in the more active volcanic subterranean mutations. Thermal agency claims the highest rank, electro-magnetic agency being secondary only, in what may be called geologic physiology; and hence we deem volcanic subterranean strata of superior rank, in contrast with these secondary classes of hypogene strata, the functions of which are mainly static and electromagnetic. We need not dwell on the alternate upheaval and subsidence of different portions of the crust of the globe, at different epochs, or by slow degrees in secular oscillations, to show the primary importance of the active subterraneous volcanic strata of heated rocks, compared with those of the secondary and more passive strata. We have then, probably, one primary class and three secondary classes of structure and of function in this, as in the other realms. The volcanic class may be deemed mainly *geodynamic*, while the secondary classes are mostly *geostatic* in character and uses.

This is not the place to enter into a minute investigation of dynamic agents, such as pressure, chemical affinities, thermo-electric phenomena, etc., in connexion with volcanic rocks and earthquakes; but these will be considered in the special study of the geospheric realm.

In the oceanic realm, there is an upper strata of aërated water descending to a certain depth, which is capable of sustaining organic life, while lower depths devoid of air are incompatible with the respiration of animals and plants. Are there three natural distinctions of azoïc waters, differing in structure and in function, in any way analogous to the hypogene classes of rock formation? Subterranean waters are certainly connected with

volcanic action in hot mineral springs, mud salses, and many other varieties of phenomena connected with geology; but some of these waters may be mainly derived from pluvial sources only. The lowest depths of sea, distinct from all volcanic action, and totally unfit for animal or vegetable respiration, form a class of oceanic strata which may well be classed apart, as having special uses, and a more condensed structure than those already named. Is there a third kind of strata set apart for special uses, which would warrant separation as a natural division in the economy and constitution of the oceanic realm? What shall we say of the polar frozen strata of the sea? Do they not form a natural class with definite and peculiar functions in the permutations and oscillations of relative density and temperature, and the consequent determination and perpetuation of currents in the sea? We have then, in this realm, as in the geospheric, one major class of oceanic strata, and three minor classes; the major being *synorganic*, and the minor simply inorganic or azoïc. The different uses of these strata are as manifest as their respective differences of constituent density; the polar ice being lighter, and the deepest waters heavier, than the aërated liquid strata. The major class alone is vital or suited to organic life, while the others are *azoïc* or unfit for respiration. The frozen constitution and peculiar uses of the polar ice are sufficiently distinct and manifest; and though the special uses of the coldest and the lowest depths of oceanic strata are not so well understood, the difference of density and temperature which renders them unfit for life, at once marks the constitution as distinct from that which is replete with living forms. The subterranean seas have their special uses in cooperation with the dynamic class of rocks to produce the oscillations and permutations of the solid crust of the earth. The generation of enormous powers

of gas and steam from these engulphed waters may be reasonably deemed one of the main uses of this class: the gradual upheaval of extensive tracts of land being the result of terrestrial heat acting upon the land-locked steaming seas beneath. Hence we have four well defined classes of oceanic strata; and one of them is major, while the other three are minor in degrees of rank and uses. Infiltrations of water from pluvial sources have, no doubt, some connection with volcanic phenomena; but it seems not impossible that vast amounts of pent-up steam derived from subterranean seas are the main causes of the gradual upheaval of whole continents. Hot mineral springs may be derived from pluvial sources, but earthquakes and geological perturbations must be caused by underground resources on a grander scale.

What of the atmospheric realm? Are there four classes of strata here as in the oceanic and the geospheric realms? There is certainly a primary distinction between the zoïc and azoïc regions of the air. Organic life is limited to the lowest strata, and this does not ascend to more than some five or six miles, not one-third of the entire altitude of the "atmospheric ocean." We have, then, a *synorganic* class of strata contrasted with the simply inorganic, here, as in the other cognate realms. In determining the different strata of the azoïc altitudes, we may proceed from the observation of distinct uses to that of constituent form and structure. The polar regions of the air are subject to the same general conditions of cold and darkness as the same regions of the ocean, and for similar purposes of determining and maintaining currents in the atmosphere, as the frozen strata of the ocean serve to perpetuate currents in the sea. Without discussing the question of constituent peculiarities of structure in the different strata of the air, we may presume, from difference of function, that the polar regions of the atmosphere

differ from the equatorial, as the frozen regions of the ocean differ from the tropical; and that in both cases, the polar strata may be classed as distinct in character from the other inorganic or *azoïc* strata. Whether open seas exist amongst the polar ice or no, and whether or no such open seas teem with organic life, may be a question for investigation, but the ice itself is certainly azoïc or unfit for life, although it may contain the relics or the germs of organic microscopic bodies entombed in its successive aggregations. The atmosphere, however, of the polar regions, would not be azoïc, if birds and other animals could live and fish in open polar seas. This class of atmospheric strata is open, then, to doubt, and will require more strict investigation. Meanwhile we know that certain altitudes of snow-capped mountains are inimical to life, and these are more or less akin to polar regions in severity of climate.

From what is known of the increasing density of air in descending from the upper to the lower depths, we may easily conceive a series of distinct strata in the atmospheric ocean,—namely, an upper, a middle, and a lower; but this hypothesis of constituent differences of density in structure is barren of result, so long as we have no idea of distinct and definite uses for each class of strata. What, then, are the respective uses of the middle and the upper secondary classes? We know the chief uses of the lower and the polar, but not so well the functions of the other two. These relate most probably to different kinds of action in the relative dynamic powers of heat and light, magnetism and electricity, as manifested in the meteoric phenomena of polar lights (aurora borealis and australis); but as little is yet known of these phenomena, we leave the question for ulterior consideration. Meanwhile it is not unwarrantably rash to suppose that one organic law rules in the constituent form and

structure, ends and uses of the strata in this realm, as we have found it conspicuously manifest in other realms. The height of the aurora borealis in (or beyond?) the atmospheric ocean has been estimated variously to be, at times, not more than fifty miles above the earth; at other times, from eighty to a hundred miles and more. There is a special use connected with magnetic light, then, in the highest strata of the atmosphere, although that use is not well understood. The highest regions of the clouds do not extend beyond two-thirds of the entire altitude; not more, perhaps, than thirty miles in height, at most. Above the lower strata of the air, where life is possible, the cold is so intense as to act upon the vapours of water in the clouds, and cause them to condense and fall upon the earth again as rain, or hail, or snow. By this contrast of temperature and density between the lower and the middle strata of the atmosphere, electrical action is originated for important uses; and therefore we may separate them as distinct and natural classes. As in the sea, we have in the air, one primary class of zoïc, and three secondary classes of azoïc strata: one class being suited to organic life, and all the others quite unsuited to such a purpose.

Magnetic luminosity and electric condensation seem to be the most characteristic features of the two upper regions, and these agree in some athermal features with the polar regions of the atmosphere; whence we may designate them as three secondary and azoïc classes of strata, in contrast with one main thermal or zoïc class.

And now, of the subordinate pluvial and reliquial realms. How are they affected by this law of distribution with regard to forms and uses? Is there one main class with three secondary classes here as elsewhere?

In the pluvial realm we easily recognise ascending mists and vapours, floating clouds, descending rains and

dews, hail and snow, running streams and small or great fresh water lakes, melting glaciers and snow beds on the mountain tops. These form an *aquapluvial* class of meteoric phenomena. Beside which we have a *gaseopluvial* class, a *pulveropluvial* class, and a *meteoropluvial* class, in the fall of lithic, metallic, and other "meteorites" properly so called. We need not specify details in each of these different classes of phenomena, as they are quite distinct and manifest. The first or aquapluvial class is decidedly distinct from all the others, and superior in relation to the uses of organic life. It is also very influential in producing the gradual changes of the geologic structure in the crust of the globe. Ammonia, marsh effluvia, carbonic acid gas, are also useful to the life of plants; and these with other gases have important uses in the general economy of epicosmic nature. The "red snow" fungus, the showers of insect excrements, and certain forms of microscopical organic "dust" carried by strong gusts of wind over immense tracts of sea, and showered down upon far distant lands, belong to a very interesting and yet little understood class of pulveropluvial phenomena, which must be influential in the general economy of nature. The origin and uses of meteorites properly so called, being still less known or understood, need not detain us here, beyond observing that they cannot be an unimportant class of natural phenomena, and may become an interesting study when science has advanced beyond its present very narrow boundaries.

The pluvial realm seems unimportant in comparison with the atmospheric, as aqueous vapour and carbonic acid gas together form but one-twohundredth part of the whole mass: but structure and uses are what we look for in all natural distinctions; and the pluvial realm is very marked and distinct as an important agency in nature. Organic realms are also unimportant in their mass, though not in structure, function, and development.

Aqueous vapour and rain-water may be held to be the same in elemental structure as the water of the sea, and therefore not entitled to distinction as a portion of a separate realm; but this is not a reason for confounding them in physical constitution and epicosmic uses. Articulate animals have vascular, nervous, muscular, and other organic systems in common with vertebrata, and yet we separate them from each other. The sea is constituted on one general type, and yet we find four classes of strata, differing from each other in habitual states and uses. The same may be said of the atmosphere with its different altitudes; and also of geological formations. The pluvial realm is of a mixed inosculatory and subordinate rank, compared with the seven greater realms; but it is nevertheless very important in connection with the sustentation and diffusion of organic life in animals and plants, as well as with the gradual mutations of the surface of the globe.

Evaporation, combustion, decomposition, and mechanical translation, are the immediate causes of the pluvial phenomena in each class; and these are the effects of heat and light, chemical affinity, gravitation, etc. "Dust storms" and other pulveropluvial phenomena are caused in part by hurricanes and violent currents of air; and not improbably volcanic eruptions of metallic and other vapours carried high and whirled away to distant parts, may be the origin of many meteorites that fall from unknown regions to the earth. The influence of the sun, exciting heat, light, electricity, etc., upon the surface of our globe, is thus the most immediate cause of meteorological phenomena, in what we call the pluvial realm. Another secondary and subordinate realm we call reliquial; and this is not an unimportant part of the economy of epicosmic nature.

The reliquial realm is mainly palæontological and

historical. The vestiges of epicosmic realms, as they existed in past ages of the world, are scattered far and wide upon the surface of the earth, or buried in the different strata of the crust. Many fossil remains of animals and plants have been already found, and not improbably more numerous relics of the past are still entombed within the bowels of the earth, to be discovered as the generations of mankind succeed each other, and interrogate these records of the globe. The organic realms have all left relics of their former types, and there is little doubt that traces of past ages and developments exist, by which we may discern the nature of the bygone states of all the inorganic realms, in their progressive evolutions from primæval ages to the present time.

Palæontological researches are still in their infancy, and the inorganic portion of reliquial investigation is little cultivated by geologists and meteorologists; but there is a history for all the realms, a chronicle of all mutations, and an epicosmological history, to be interrogated as the sciences advance, and give us power to interpret all the records of the past. Much is already known of past mutations in the solid shell or crust of the earth, but not of past mutations of the atmosphere, the ocean, and the elemental realm; not to mention the pluvial and the reliquial realms and their respective transformations. Traces of all past states no doubt exist, and may be found, when once the mind is thoroughly awakened on the subject, and researches have been duly instituted.

Besides the history of all the realms recorded in the vestiges of past divine creations and phenomenal mutations, there is a history of human creations and sociological revolutions recorded in the vestiges of human industry and art, science and religion, handed down to us in revelations and traditions, archæological remains, and traces of man's existence in the prehistoric ages of the

world; and these form a connective division of the reliquial realm. The main distinctions in this realm then, are *realmic* and *sociological*, the one being primary, and the other secondary in importance. And here, again, the inferior division forms three classes of phenomena, which are industrial, artistic, and scientific. REALMIC reliquiæ, *industrial* reliquiæ, *artistic* reliquiæ, and *scientific* reliquiæ or historical records, give us, then, four classes in this realm as in all the others; and a methodical analysis of each of these four classes will be one of the most interesting branches of organic science and philosophy.

The Elemental realm.—The realm of elemental matter with which organic and inorganic forms are invested in their multifarious mutations and developments, is quite distinct from forms and forces in themselves, as manifested in all other realms. Form and structure, use and function are alone considered in the vertebrata, articulata, mollusca, radiata, phanerogamia, and cryptogamia, irrespective of the elemental substances contained in any special organism; and the same may be said of crystals and other special types of physical form and structure in the geospheric, oceanic, atmospheric, pluvial, and reliquial realms. Anatomy, physiology, and kindred sciences are mostly interested in the study of organic realms as such; geology, meteorology, hydrography, atmology and kindred sciences are mainly interested in the study of the inorganic realms respectively. Chemistry, mineralogy, and physics, properly so-called, are interested in the study of the elemental realm. Matter, as matter, then, and almost irrespective of the inorganic and organic realms in which it is subservient to the uses of peculiar forms and structures of a higher order, is the subject to be here considered. What are the special forms of matter, merely as matter, apart from any special forms of the organic or inorganic bodies with which it is connected? and how

many kinds of elemental matter are there in any one body, organic or inorganic? or in all the bodies of the epicosmic world? for matter permeates or clothes the forms and forces of all epicosmic realms. It is in them or with them, but not of them, being a distinct form of power and structure in itself.

The simplest elements of matter known to chemists are commonly divided into two sections, *i.e.*, *metallic* or *non-metallic;* but men of science differ in their views regarding these and other distinctions of elemental substance. Some chemists class hydrogen with the metallic elements, others, with the non-metallic. Arsenic is generally classed as a metallic element; Gerhardt places it with phosphorus and nitrogen, as a non-metallic body. There is some confusion, then, and not a little difference of opinion, amongst chemists, with regard to the natural place of certain elements, in a general arrangement. The metallic and the non-metallic elements, however, are deemed quite distinct and different from each other, where the properties of each are well contrasted; while a few ambiguous elements are still a puzzle to the systematic chemist, to know where to place them, in their natural position.

We need not dwell at present on these controverted points, but first observe that the most stable elements are commonly metallic, while the more unstable are the non-metallic. These elements are variously formed into kindred groups by different chemists, and a final order of arrangement is, perhaps, impracticable now. Gerhardt establishes five groups of non-metallic elements, and seven or eight groups of the metallic. Other chemists give us very different arrangements. We do not know enough of chemistry ourselves to give an enlightened opinion on these differences. All that we can do, will be to give a general view of the question, and a tentative synopsis of a natural classification.

The abstract theory of natural organic method, suggests that one main class and three connective classes may be found in this as well as in all other realms; and if we make a primary distinction between elements already fixed in living bodies, and those which are set free by dissolution and decay, we shall have one main class and three secondary classes of elementary bodies, in the permanent unity of the epicosmic world. The elements which are constantly being dissolved by the wear and tear of animals and plants, and liberated as waste matter by excretions, form one class of what may be called free elements: the dissolution and decay of all dead bodies form a second class of these dissolving elements; and the natural decompositions of inorganic bodies, form• a third class of unfixed elements.

In the main class of fixed elements we have twelve orders or alliances. Different combinations occur in each of the twelve realms (those of the elemental realm proper, being simple elements which rank as independent bodies, such as gold and silver), and these different combinations form natural alliances. In the realms we have six orders of free elements, in the egestive class; six in the organic dissolution class; and six more in the inorganic dissolution class.

The atmospheric order of elements contains *nitrogen* and *oxygen* as constituent substances; the water of the ocean, *hydrogen* and *oxygen;* and mineral bodies contain different kinds of elements in their special structure. All these questions will be dealt with in detail, when we analyse the elemental bodies; meanwhile we give an outline only of the primary and secondary classes of each realm.

One common law of primary divisions in each realm, as here suggested, may seem unwarranted in principle, and arbitrary in its application, until corroborated by a long

and critical investigation. It may, indeed, be true in principle, and yet defective in more points than one of our illustration. But is there no necessity for some such method of distinction to complete the numerous shortcomings and perplexing disagreements of inductive method, as applied by those who cultivate the natural sciences? Is it possible, without an organic standard of perfection as a type of multiple diversity in unity, to bring together in one simple whole the very numerous and various details of nature? Experience proves that it has not been possible, as yet; for all the leading naturalists of the present age differ from each other and from those of former ages, in their general methods of arrangement.

We take the human body as a type of organic unity, in which a complex multiplicity of organs is reduced to order in cooperative life and uses, and we *suppose* that one law of order rules in all the complex unities of nature. Is this hypothesis admissible? And can we learn to work it as a method, if it be true in principle? We believe it to be true, and not too difficult to analyse, in order to discover the laws of natural organic method; but many partial failures may occur before the perfect law has been explained. The natural distinctions of realms and primary divisions in each realm, as here pourtrayed in outline, we deem undeniable; but those of classes and sub-classes, alliances and sub-alliances, require elaborate consideration, and difference of opinion on these points, may be expected, until science has made further progress.

The primary divisions of each realm are manifest and easily recognised, and these are all that we need speak of for the present. Minute developments are found in all the best works of natural history, and to these we may refer the reader for details. The following synopsis of

the twelve realms and their primary divisions, we give here as a general summary of what has been said above; and this will be completed by the addition of what may be called the connective forms and forces of the epicosmic universe.

SYNOPSIS OF EPICOSMIC REALMS AND CLASSES.

Realms.	*Divisions.*	*Classes.*
VII. Vertebrata.	Vivipara. Ovipara.	1. Mammalia. 2. Birds. 3. Reptiles. 4. Fishes.
·7. Articulata.	Articulata. Annulosa.	1. Crust-Arachnida. 2. Insecta. 3. Myriapoda. 4. Annelata.
VI. Mollusca.	Cephala. Acephala.	1. Cephalophora. 2. Lamellibranchiata. 3. Palliobranchiata. 4. Heterobranchiata.
·6. Radiata.	Holothuriata. Radiata.	1. Holothuria. 2. Echinodermata. 3. Cœlenterata. 4. Protozoa.
V. Phanerogamia.	Dicotyledona. Monocotyledona.	1. Exogens. 2. Perianth-endogens. 3. Aperianth-endogens. 4. Aquatic endogens.
·5. Cryptogamia.	Acrogens. Thallogens.	1. Acrogenales. 2. Lichenales. 3. Fungales. 4. Algales.
IV. Elemental.	Fixed Elementa. Free elementa.	1. Organalia. 2. Egestiva. 3. Necrologia. 4. Erosiva.
III. Geospheric.	Geodynamia. Geostatica.	1. Volcanic Class. 2. Metamorphic ,, 3. Plutonic ,, 4. Magnetic ,,
·2. Reliquial.	Realm Reliquia. Social reliquia.	1. Realmic Vestiges. 2. Industrial remains. 3. Artistic remains. 4. Scientific remains.
II. Thalattospheric.	Synorganic. Inorganic.	1. Zoothermal Seas. 2. Frozen seas. 3. Deep azoïc seas. 4. Subterranean seas.
·1. Pluvial.	Aquapluvial. Alteropluvial.	1. Aquapluvia. 2. Gaseopluvia. 3. Pulveropluvia. 4. Moteoropluvia.

I. ATMOSPHERIC.	SYNORGANIC. Inorganic.	1. ZOOTHERMAL STRATA. 2. Polar strata. 3. Meteoric strata. 4. Auroral strata.

EPICOSMIC UNITY.

IF the individual body be the type of all organic unity, it must afford an illustration of the law of epicosmic unity. But how are we to find the parallel ?

The human body is a complex unit of the vertebrate realm, and the vertebrate realm is a complex unit of the terrestrial epicosm : which is itself a complex unit of the globe : but the last point is not a question for immediate investigation, our present inquiry being limited to epicosmic nature.

We have, then, three degrees of complex unity ; individual, realmic, and epicosmic. Any realm is a complex unit of the epicosm to which it may belong, and any individual is a complex unit of the realm to which it may belong. We take the highest organic realm as a typical unit of the epicosm, and the highest individual type, as an organic unit of the vertebrate realm. Let us, now, compare the three, to find a parallel in illustration of the one organic law.

The first analytical degree gives us two primary distinctions in each case : thus—

Complex individual organism.	Special organic tissues. General connective tissues.
Complex realmic organism.	Viviparous vertebrata. Oviparous vertebrata.
Complex epicosmic organism.	Realmological creations. Sociological creations.

Realmological creations are divine ; sociological creations are mainly human. Still, the law of unity is manifest in the epicosmic organism, as well as in the realmic and the individual organisms.

Man is not the only sub-creator on our globe, but he is the chief centre and ruler of secondary constructions. The lower animals build coral reefs in the sea, and many other kinds of geological formation on the crust of the earth. Many kinds of physiological, geological, and industrial creation proceed from the minute beings of all organic realms, but the most remarkable of secondary epicosmic creations are produced by human nature, when organised in society, and trained by collective education or civilisation. Much has been done already to mark the importance of mankind as a collective force in epicosmic development, but more may be expected from the future progress of the human mind and civilised society.

ZOOLOGICAL THEORIES.—"Man's place in nature" is beginning to attract attention amongst men of science; not his epicosmic place, as a creator and a ruler in co-operation with Deity, but his *physiological* place amongst the germinal vesicles of incipient organic structure, and his *osteological* or structural place amongst mammalia. These questions are not unimportant, and men of special science have done good service in observing carefully and explaining facts of structure and affinity, which were unknown before, or quite misunderstood; but special science too exclusively pursued, gives a bias to the judgment which both limits and warps the understanding. This has been the case, we think, with Mr. Huxley and Mr. Darwin in their respective views of 'physical causation' and organic developments. Comparative anatomy and physiology are very important sciences, but they mislead the mind as much as they enlighten it, when too exclusively pursued without the guidance of a general principle.

It is not our business to dwell on facts of special science beyond that which is necessary for our present purpose; but we must observe that man has more than

one place in nature, and more especially collective man, sociologically organised and civilised. We do not dispute the facts adduced in proof of a particular view of human nature, anatomically and physiologically considered, but we demur to the philosophical and religious implications of crude theory. Physical nature is not the supreme Creator; physical man is not creative man. A few words on this point may be of use to us in our inquiry.

We do not wish to espouse the quarrel of the 'righteous overmuch' of whom the men of special science complain, nor do we wish to restrain the speculative liberty of 'natural selection' theorists, but we do wish to show the insufficiency of 'physical causation' as a basis of organic philosophy and hypothetical speculation. Not to misrepresent the views in question, we quote from Huxley's recent work on "Evidence as to Man's Place in Nature" the following remarks: but first let us give our own view of man's place in nature, as an animal. Man is a vertebrate animal; so is a fish: but man is a mammal: a fish is not. Man is a mammal: so is a pig: but man is a primate; a pig is not. Man is a primate, then; so is a monkey: but man is an erectograde primate; a monkey is not. Man is pedigrade; exclusively: the gorilla is not. And this difference is structurally almost as great as that between the dog, a digitigrade, and the bear, a plantigrade; both of which belong to Cuvier's unnatural "carnivorous" order, as much as men and apes belong to the unnatural order of "primates." And here we may observe, that looking at the teeth mainly, in connection with all the structural characteristics which are syncretic with the teeth of a carnivorous animal, Cuvier was just as much warranted in forming his carnivorous order, as Huxley in adopting the antiquated order of "primates." On structural grounds alone then, we reject both Cuvier's

"carnivora" and Linnæus's "primates" as natural orders. But let us quote Huxley's own statement (pages 103, etc.). "Thus, whatever system of organs be studied, the comparison of their modifications in the ape series leads to one and the same result—that the structural differences which separate man from the gorilla and the chimpanzee are not so great as those which separate the gorilla from the lower apes." (Here we might observe that the difference which separates the badger from the bear is not so great, apparently, as that which separates the lion from the badger: still the latter are allied; the former not).

"But in enunciating this important truth I must guard myself against a form of misunderstanding, which is very prevalent. I find, in fact, that those who endeavour to teach us what nature clearly shows us in this matter, are liable to have their opinions misrepresented and their phraseology garbled, until they seem to say that the structural differences between man and even the highest apes are small and insignificant. Let me take this opportunity then of distinctly asserting, on the contrary, that they are great and significant; that every bone of a gorilla bears marks by which it might be distinguished from the corresponding bone of a man; and that, in the present creation, at any rate, no intermediate link bridges over the gap between *homo* and *troglodytes*.

"It would be no less wrong than absurd to deny the existence of this chasm; but it is at least equally wrong and absurd to exaggerate its magnitude, and resting on the admitted fact of its existence, to refuse to inquire whether it is wide or narrow. Remember, if you will, that there is no existing link between man and the gorilla, but do not forget that there is a no less sharp line of demarcation, a no less complete absence of any transitional form, between the gorilla and the orang, or the

orang and the gibbon. I say not less sharp, though it is somewhat narrower. The structural differences between man and the man-like apes certainly justify our regarding him as constituting a family apart from them; though inasmuch as he differs less from them than they do from other families of the same order, there can be no justification for placing him in a distinct order."

Here we might ask Mr. Huxley how he would account for any sharp lines of distinction, either small or great, on the principle of natural selection? And as he admits sharp lines of demarcation, what are his grounds for supposing one sharp line of distinction to be less important than another? What does he mean by an order as different from a family? as this is a point on which all naturalists have differed more or less. But to proceed.

"And thus the sagacious foresight of the great lawgiver of systematic zoology, Linnæus, becomes justified; and a century of anatomical research brings us back to his conclusion, that man is a member of the same order (for which the Linnæan term, PRIMATES, ought to be retained) as the apes and lemurs. This order is now divisible into seven families of about equal systematic value: the first, the ANTHROPINI, contains man alone; the second, the CATARHINI, embraces the old world apes; the third, the PLATYRHINI, all new world apes, except the marmosets; the fourth, the ARCTOPITHECINI, contains the marmosets; the fifth, the LEMURINI, the lemurs; from which cheiromys should probably be excluded, to form a sixth distinct family, the CHEIROMYINI; while the seventh, the GALEOPITHECINI, contains only the flying lemur, *galeopithecus*,--a strange form, which almost touches on the bats, as the *cheiromys* puts on rodent clothing, and the lemurs simulate insectivora.

"Perhaps no order of mammals presents us with so extraordinary a series of gradations as this, leading us

insensibly from the crown and summit of the animal creation down to creatures from which there is but a step, as it seems, to the lowest, smallest, and least intelligent of the placental mammalia. It is as if nature herself had foreseen the arrogance of man, and with Roman severity had provided that his intellect, by its very triumphs, should call into prominence the slaves, admonishing the conqueror that he is but dust."

Here we may pause to ask what nature the author alludes to in this religious peroration. Is it to physical nature or to moral nature? And if to the latter, why bear so timidly on physical causes alone for an explanation of organic genesis and development? And is it not quite as remarkable that man should be the only animal in which a religious soul can be developed, as that he should be structurally placed at the head of a progressive series of forms beginning at the lowest stage of mammalian development? The human body is inferior, as an instrument of animal life, to that of many other types when placed in rude conditions; but the human mind gives power to the body which no animal can ever match. The facts of structure, on which so much stress is laid by Mr. Huxley, are really of no importance when compared with those of a higher order; and therefore his conclusions are invalid in establishing man's real place in nature. But to continue our quotations.

"These are the chief facts; this the immediate conclusion from them, to which I adverted in the commencement of this essay. The facts, I believe, cannot be disputed; and if so, the conclusion appears to me to be inevitable.

"But if man be separated by no greater structural barrier from the brutes than they are from one another, then it seems to follow that, if any process of physical causation can be discovered by which the genera and families of ordinary animals have been produced, that process of

causation is amply sufficient to account for the origin of man. In other words, if it could be shewn that the marmosets, for example, have arisen by gradual modification of the ordinary platyrhini, or that both marmosets and platyrhini are modified ramifications of a primitive stock, then there would be no rational ground for doubting that man might have originated in the one case by the gradual modification of a man-like ape; or, in the other case, as a ramification of the same primitive stock as those apes."

Even so. What then? Does physical causation, or the starting-point of physical evolution, explain man's soul, or the creation of his mind? Does the soul create the body, or the body generate the soul? That is the fundamental question. But, accepting the hypothesis of physical causation, it cannot be too much to ask how and when the inferior races of mankind emerged from the apes, and by what steps the superior races were gradually evolved from the inferior? Did the gorilla give origin to the lowest African negro type, and this to the next above it, until the Nubians and the Abyssinians gave birth to the Egyptians and Assyrians as generators, in their turn, of the Jews and Persians, the lost tribes of Israel giving origin to all the modern European races? Did the Australian aborigines derive their origin from the Bornean ourang outang, and then give birth to the Malays and Oceanic tribes; and these, again, give origin to the Mongolian races, Chinese, Tatars, American Indians, etc.? And if so, how many centres of origin and dispersion could be traced by a careful investigation of this simplest of all natural selection questions? It cannot be deemed a difficult question to decide, for Mr. Huxley goes on to say that, "At the present moment, but one such process of physical causation has any evidence in its favour; or, in other words, there is but one hypothesis regarding the origin of

species of animals in general which has any scientific existence, that propounded by Mr. Darwin; for Lamarck, sagacious as many of his views were, mingled them with so much that was crude, and even absurd, as to neutralise the benefit which his originality might have effected had he been a more sober and cautious thinker; and though I have heard of the announcement of a formula touching 'the ordained continuous becoming of organic forms,' it is obvious that it is the first duty of a hypothesis to be intelligible, and that a *qua-quâ*-versal proposition of this kind, which may be read backwards or sideways with exactly the same amount of signification, does not really exist, though it may seem to do so.

"At the present moment, therefore, the question of the relation of man to the lower animals resolves itself, in the end, into the larger question of the tenability or untenability of Mr. Darwin's views. But here we enter upon difficult ground, and it behoves us to define our exact position with the greatest care.

"It cannot be doubted, I think, that Mr. Darwin has satisfactorily proved that what he terms selective modification must occur, and does occur, in nature; and he has also proved to superfluity that such selection is competent to produce forms as distinct, structurally, as some genera even are. If the animated world presented us with none but structural differences, I should have no hesitation in saying that Mr. Darwin had demonstrated the existence of a true physical cause amply competent to account for the origin of living species, and of man amongst the rest." The origin of mere diversity of form and structure, surely; not the origin of form and life. There must have been a selective principle of form and force before selection could occur.

"But in addition to their structural distinctions, the species of animals and plants, or at least a great number

of them, exhibit physiological characters; what are known as distinct species, structurally, being for the most part either altogether incompetent to breed one with another; or, if they breed, the resulting mule or hybrid is unable to perpetuate its race with another hybrid of the same kind.

"A true physical cause is, however, admitted to be such only on one condition,—that it shall account for all the phenomena which come within the range of its operation. If it is inconsistent with any one phenomenon, it must be rejected; if it fails to explain any one phenomenon, it is so far weak, so far to be suspected; though it may have a perfect right to claim provisional acceptance.

"Now Mr. Darwin's hypothesis is not, so far as I am aware, inconsistent with any known biological fact. On the contrary, if admitted, the facts of development, of comparative anatomy, of geographical distribution, and of palæontology, become connected together, and exhibit a meaning such as they never possessed before; and I, for one, am fully convinced that, if not precisely true, that hypothesis is as near an approximation to truth as, for example, the Copernican hypothesis was to the true theory of the planetary motions."

"But for all this, our acceptance of the Darwinian hypothesis must be provisional so long as one link of the chain of evidence is wanting; and so long as all the animals and plants certainly produced by selective breeding from a common stock are fertile, and their progeny are fertile with one another, that link will be wanting. For, so long, selective breeding will not be proved to be competent to do all that is required of it to produce species.

"I have put this conclusion as strongly as possible before the reader, because the last position in which I wish to find myself is that of an advocate for Mr. Darwin's, or any other views—if by an advocate is meant

one whose business it is to smooth over real difficulties, and to persuade where he cannot convince.

"In justice to Mr. Darwin, however, it must be admitted that the conditions of fertility and sterility are very ill understood, and that every day's advance in knowledge leads us to regard the hiatus in his evidence as of less and less importance, when set against the multitude of facts which harmonise with, or receive an explanation from, his doctrines.

"I adopt Mr. Darwin's hypothesis, therefore, subject to the production of proof that physiological species may be produced by selective breeding; just as a physical philosopher may accept the undulatory theory of light, subject to the proof of the existence of the hypothetical ether; or as the chemist adopts the atomic theory subject to the proof of the existence of atoms; and for exactly the same reasons, namely, that it has an immense amount of *primâ facie* probability: that it is the only means at present within reach of reducing the chaos of observed facts to order; and, lastly, that it is the most powerful instrument of investigation which has been presented to naturalists since the invention of the natural system of classification, and the commencement of the systematic study of embryology."

Mr. Huxley admits that there is a link wanting in the Darwinian hypothesis, but he does not admit that there is a link wanting in the "invention of the natural system of classification" according to anatomic structure, by which he decides on man's place in nature. He gives his decision on the simple grounds of comparative osteology and myology. On these grounds Cuvier, long ago, classed the horse as a genus of the pachydermal order. Vicq d'Azyr placed the horse in a distinct order. In this case, Cuvier was no doubt wrong; Vicq d'Azyr right. A man of genius, such as Cuvier, may therefore be misled some-

times by keeping osteological structure and comparison alone in view, where other structural characteristics are more important and distinctive. As in the case of pachydermal groups, in which the trunk of the elephant, the truncate proboscis of the tapirus, the rooting snout of the pig, and the ploughing and rooting habits of the rhinoceros, not to mention the extraordinary thickness of the skin in all these animals show their leading characteristics of both habit and general structure to be of one common order; while the horse is manifestly a distinct type both in structure and in character. The skin gives the characteristic distinction of the pachydermal order; the head and face, or trunk and snout, give the family groups or series; while the general and osseous structure indicate the genera and species in subordination to the other two. So in man, the powers of speech and thought give the characteristic of the order homo: which is quite as far removed from the order simia or quadrumana, as the equine order from the pachydermal.

Mr. Huxley is no doubt a very eminent naturalist, and on osteological and myological grounds, he places man in the same order as the apes, while he severs bats from monkeys, on the same grounds of comparative structure; although he admits that the "flying lemur" is very nearly allied to the larger bats. Nature places the bats, the roussettes, and the galeopithecus, in the same anomalous series, and this series we place in the pithecine alliance; from which we separate man, as the type of a distinct order; not indeed on osteological grounds alone, or chiefly, but on other structural and functional considerations; not to mention sociological grounds, which are of primary importance, in addition to those of physical structure. Cuvier himself, though greatly influenced in his judgment by osteological affinities, as evinced in the case just mentioned, places man in a distinct order, not-

withstanding the example of Linnæus in forming his order of primates.

Comparative anatomy, then, and especially comparative osteology, too exclusively consulted, are apt to bias the judgment; they both limit, contract, and warp the understanding in questions of natural arrangement: and Mr. Huxley is evidently not more free from bias, on this point, than Cuvier was, in the same line.

What now of the "physical causation" theory of genetic evolution from the simplest germs of "structureless ova;" and the subsequent developments and metamorphic origin of species by "natural selection"?

This theory implies that all organic types originate, at first, in simple cells, and are developed from these cells or ova, by the physical conditions that surround them during incubation and subsequent development: and further that, as it is a "wholly unquestionable fact that man was once an egg, which no ordinary power of discrimination could distinguish from that of a dog," we may infer that all organic life originates in eggs, or homogeneous matter; and that organic form and structure, instinct and reason, are developed from these formless germs, by incubation and natural selection: and were it not for the "missing link" of physiological reproduction between different species, this hypothesis would be deemed sufficient and legitimately scientific.

On the physical plane of thought, we may easily admit this hypothesis; for we see that all the organs of the human body are evolved from a single vesicle, and the plastic elements which surround this vesicle. We also see that, in this body thus educed from a simple cell, the mind of man is gradually developed in its highest powers. We have also seen that there is nothing more complex in a collective organism or realm than in an individual organism or unit: nothing more complex in an

epicosm than in the human body; nothing more complex in the psychology of any epicosmic organism than in the mind of man; nothing more complex in the sociological forces of the epicosm, than in the human soul, which is the essence of those sociological forces. It is not the physical aspect, then, which puzzles us in this hypothesis. Another link is wanting—the architypal link. An ordinary observer of physical facts alone might easily observe a palace arise from a single foundation stone; a church likewise; a peasant's cottage; and a theatre. All these might be attributed to the natural selection of those different kinds of stones and buildings: but instead of forming this hypothesis, we read the architect's mind in the plan of the edifice, and not the natural selection force of single stones: we read the divine mind in natural organisms: and not the mysterious "physical causation" powers of simple cells.

We do not object to the study of "secondary causes;" nor do we deny the importance of this order of facts; but we do object to the habit of substituting secondary causes for primary causes, or otherwise ignoring the latter altogether, in the philosophy of creation. That savages build only simple sheds for homes, in tropical regions, while civilised men build solid walls and roofs for their castles and their homes in sterner climes, is an interesting fact; and that difference of climate and condition has much to do with this difference of structural phenomena, is manifest; but "natural selection" in accordance with physical conditions, is a very complex question, not to be explained by the study of climate alone, or external conditions, or "physical causation," in this secondary sphere of creation. Besides the climatic stimulants which modify man's mode of action, or "natural selection," we have the man himself who acts; and mind is more important as a *mental factor*, than the difference of climate as a *physical factor* in the parallel forces of causation.

External nature is one thing, as a "secondary cause," and God is another, as a primary cause. That God ordains a certain order of nature, and then adapts minor forms and forces to more important general conditions and mutations, is probable, according to human ideas of order and sequence; but to ignore living thought as the primary cause, and dwell exclusively on elemental nature or "physical causation," is a dangerous one-sidedness of method, meriting impartial criticism as much as the opposite superstition, referring to God without regard to laws or circumstances, which induce the Divine mind to give particular forms to elemental forces in creation.

The world is, nevertheless, benefited by this new method, which calls attention to the influence of external conditions in the evolutions of organic realms; for the study of nature has been much neglected by those who think of God as the Creator, without endeavouring to understand the plan of the Great Architect, or to commune with the Omnipotent, in the sphere of His creative reason. Veneration and religion are no excuse for this neglect; which seems to come from mental weakness rather than from love of truth, which also is religion.

We are not alone, however, in dissenting from the "physical causation" theory, for the late Professor E. Forbes, who stands as high as any of the great naturalists of this age, has put forth views which we accept on this vexed question of the origin of species. In a letter to the late Baden Powel, published in his *Philosophy of Creation*, Professor Forbes explains his views in the following series of propositions, which we quote in full:—

"1. A specific centre of creation is an area occupied by the individuals of a species.

"2. It is an ascertained fact, that numerous well-marked *provinces* of the earth and sea can be indicated, each characterised by a flora and fauna, on the whole peculiar to itself.

"3. A *species* absolutely peculiar to a *province* has necessarily its centre within it; but many species are common to two or more provinces.

"4. As a rule, when a species is common to two or more provinces, these provinces are contiguous, and consequently, the specific area is continuous.

"5. But there are exceptions, such as a species, or a group of species, exhibiting in some cases the phenomenon of occupying more than one area, or of presenting outliers of individuals separated from the main assemblage.

"6. But when we sift the history of such exceptions, we find, that by tracing back the history of the distribution of the species, or group of species, so situated, in time (*i.e.*, their geological history) we can show the strong probability of an epoch when all the individuals of the species in question occupied a continuous and unique area.

"7. Hence an inquiry into the distribution of the individuals of a species in both time and space, results in the maintenance of the theory of the *unity of specific centres.*

"8. Moreover, when we are able to trace the history of a species in time, we find, in the majority of instances, that there is a distinct indication of a paucity of individuals, as we approach the epoch of its first appearance.

"9. And when we are dealing with well-marked and continuous areas of species belonging to the present epoch, we find that there is within such area the indication of a point of maximum development of individuals, around which the numbers diminish.

"10. We infer from these facts (8 and 9) the probability of a single point of origin for every species within its centre of occupation.

"11. In the course of time, however, it is possible that

the area of occupation of a species may become removed from the point of origin, or may, after being removed, eventually return to its original position.

"12. The indications of a single point of origin for each species, combined with the fact that we have no knowledge or experience of the individuals of any species being produced otherwise than from individuals of its own kind—in other words, that we have no knowledge of any other relationship between the individuals of a species than that of *descent*—leads to the inference that each species originated from a unique stock or prototype, consisting of a single being, or pair of beings, according as would be required for propagation.

"13. Hence the point of origin within a specific centre is the point of appearance of the prototype.

"14. How that prototype originated we know not; but the doctrine of specific centres, originating each with a prototype of its own, is necessarily opposed to the hypothesis of *the evolution* of all species from one first form, without respect to the superiority or inferiority of the form.

"15. That the prototype presented the *specific characters* (*i. e.*, distinctive and constant features) of its descendants, is an hypothesis rendered probable by all that we know of the history of species in space and time.

"16. The observation of the distribution of species in space and time indicates geographical areas and chronological epochs—points in time and space—where, as it were in preference, many species originated in groups. These we term *centres of creation,* and the phenomena of provinces are linked with the existence of them.

"17. The value of palæontology to geology depends on the assumption of the constancy of specific types, and the unity of their centres or areas of occupation in time.

"18. What is true with existing species should be

à priori true with extinct ones, since we can clearly show that all known creatures, recent and fossil, are members of one biological system."

We quite agree with the hypothesis upheld in these propositions, but we cannot admit that this hypothesis, as here set forth "is necessarily opposed to the hypothesis of *the evolution* of all species from one first form;" for the advocates of the "natural selection" theory do not say "without respect to the superiority or inferiority of the form." They admit, successive stages of evolution from lower to higher, and still higher, in all directions of organic unity of plan, in each of the distinct organic realms.

As Professor E. Forbes admits, "we know not how the various prototypes of species originated." Nor does it affect the question of creation at all to decide between the two conflicting theories of physical origin, for God may just as easily, for aught we know, give bodily form to a new species of animal instinct, by modifying and improving the embryological development of an allied inferior species of ova, as by creating a new and distinct ovum for the incarnation of a new species. That which is repugnant to our reason, is the doctrine of "physical causation" and mere "natural selection."

The Rev. Baden Powel has discussed the question with much candour and impartiality; but we cannot think with him, that it is quite independent of religion and of faith in the principle of mental causation in the divine mind. Once admit that "physical causation" and "natural selection" are sufficient to account for all natural creations, and that divine revelation in the Scriptures is merely the "offspring of devout reason in the human mind" on this natural plane of life, and we do away with the necessity for faith in the existence of another world, and of a Divine Mind as the Creator and Ruler of the uni-

verse. It is repugnant to all the dictates of intuitive reason and faith in immortality; and to this extent it is hostile to religion,—not perhaps intentionally, but implicitly.

Admitting the hypothesis, however, of those divines who suppose that Revelation is merely the out-birth of devout reason in the Church, we may test the question by asking what they understand by the words "prophet" and "prophetic inspiration"? Do the angels of God and His ministering spirits communicate heavenly wisdom to mortal beings in this natural world? Or do the prophets who speak of receiving such communications through the medium of voice and vision, delude themselves and all believers? The "devout reason" theory seems to deny the fact of Revelation from the ministering angels of God in another world; and this denial strikes at the very foundations of religion. We must not impugn Revelation in order to reconcile human science more easily with scriptural teaching.

Those who make the Scriptures a stumbling-block on account of literal discrepancies and contradictions, confound the kernel of spiritual truth with the husk of traditional conservation; and show weakness by declaiming against the fruit itself, because divines tell them that the husks are as sacred as the kernels, in all Bible fruits. Some advise the laity to swallow the whole sacred fruit, husk and kernel together; or put it into a creed-safe, and hope they may be saved by faith alone in the goodness of the fruit, without eating it at all. This mode of treatment avoids intellectual indigestion, and secures a trustful peace of mind; but those who try to swallow the husk and kernel together, without any logical separation, are often troubled with mental indigestion, and imagine that such entangled premises can furnish rational arguments against the genuine nature of the fruit. It is a

great mistake, arising mostly from the negligence of those who ought to separate the kernels from the shells, when they feed their flocks with spiritual food.

We do not wish to foster superstition and intolerance; but we do wish to neutralise erroneous theories and criticisms, by fair investigation. We deem it an awful calamity for the human race, that the Divine face of Christ, so gloriously bright with healing benevolence in the Gospel, should be veiled from the eyes of common sense, by the hideous masks of crude theology; as the glorious face of the sun is hidden by clouds of burning sand in the desert; happily such calamities are not perennial; and God-with-us is everlasting.

The superstitious reverence for antiquated revelations which mars the face of Christianity, is also a cause of much bickering perplexity that might be easily avoided by a strict adherence to the Gospel. We might as well attempt to revive extinct races of antediluvian reptiles, as to galvanise with seeming life extinct forms of pristine revelation. The Old Law has been partially abolished by the New. "An eye for an eye, and a tooth for a tooth," are extinct forms of doctrine. The Sermon on the Mount brought us new forms of revelation in lieu of those which it replaced: as the Creator introduced new forms of life to supersede extinct types in the revolutions of the globe.

Secondary causes are important, and deserve most careful study: but they are not physical alone. Man himself in his collective organisation, is a powerful creator; and other organic forms and forces act as secondary causes of mutation on our globe. But man is a combination of moral, mental, instinctual, and physical forces, giving birth to moral, mental, instinctual, and physical creations, in his social, scientific, artistic, and industrial inventions.

Higher secondary causes of creation than man may cooperate with God in the universe, for anything we know to the contrary; nor would any of these secondary causes interfere with the great primary cause, or diminish the glory of omnipotence in the creation. It is not the idea of 'secondary causes,' then, which is repugnant to the highest faith and reason, in our nature, but that of "Physical causation" without mind, as an essential factor of creative power; and law, as a guide to the creative mind.

It is not an idle question to ask whether a viper, a tiger, or any other noxious creature, be the result of primary or secondary causation; and if the former, whether it be in adaptation to particular conditions of time and circumstances, in the progress of the world; or whether it be independently of all considerations of order and sequence in the Divine mind. We may not be able to obtain at once an answer to such questions; but we may believe that there is nothing hid which shall not be made known, to those who seek truth for love and wisdom's sake.

We may also observe that, although secondary causes may be alone within the reach of human understanding, they are necessarily subordinate to primary causes in the creative mind. We not only admit a primary cause, then, but secondary causes of a higher order than that of "physical causation:" and herein we differ from those naturalists and philosophers who adopt the "natural selection" theory.

Divine creations are easily disposed of on the very simple and "satisfactory" hypothesis of "physical causation." But what of the inferior domain of human creations? Would a theory of architecture or mechanical construction be received on the plea of physical causation? Could it seriously be propounded that the origin

of oriental or Egyptian architecture could be traced to the peculiar nature of the bricks or stones of which the houses, palaces, and temples were at first constructed; and that by a gradual process of intermingling stones and bricks derived from different regions of the globe, the Grecian styles of architecture had been slowly evolved by something like a process of natural selection and adaptation to the varying conditions of climate; and that former styles of architecture had been lost as Greek succeeded Egyptian, Assyrian, and other African and oriental types, Roman succeeded Greek, and Gothic Roman, until modern architecture had become a sort of intermingling of many ancient styles with many various and more modern styles of architectural construction? Or in the sphere of more complex and intricate mechanical construction, would it be believed that a locomotive and a water-wheel, a Dutch clock and a watch, were mere developments of iron or brass or wooden levers, which originated in homogeneous metallic ores, or in the broken branches of antique trees which slowly, by a process of mysterious incubation, became simple levers, and by accidental combinations first became hammers, crowbars, floating rafts, canoes, shovels, wheelbarrows, carts, boats, barges, ships, Dutch clocks, clumsy watches, exquisite chronometers, water-wheels, windmills, hydraulic machines, steam engines, and locomotives? The hypothesis is evidently too absurd to account for human creations or constructions; but not, apparently, too silly to account for superhuman or divine creations.

The parallel, it will be said, is not legitimate nor "scientific." Certainly not. But which side of the parallel is most absurd?

Discarding altogether the hypothesis of "physical causation" in the metamorphic evolution of organic forms from simple ova, we may understand the influence of "natural selection" in modifying and improving or deteriorating

species in both human and superhuman developments. Architecture and machinery may be modified by "natural selection," or experience and ingenuity; and faculties or organisms may be, and often are, improved or modified by training and experience in animals, by the crossings of breeds and more favourable cultural conditions in plants; but still the "link is wanting" to prove that species can be permanently changed by any process known to man, or widely different types be generated by the unnatural or accidental interminglings of the germs of one species with those of another.

What does the hypothesis amount to, then, in any point of view, scientific or otherwise? Merely to the possibility of progress and improvement in natural and definite species by culture, education, favourable circumstances, and natural selection, on the part of organic beings endowed with instincts or intelligence, selective tastes, and reproductive affinities. None of which exist in simple ova, either animal or vegetable, except mere physical affinities, before they are superinduced from occult forces of a higher order by means of incubation and the conditions necessary to organic evolution: just as bricks and stones physically and mechanically fit for architectural constructions, become walls and chambers, houses, palaces, and temples, by mental and physical or industrial incubation in the midst of favourable circumstances and conditions.

In all known cases of human experience, instinct or mind gives form to matter; but matter never creates mind, or gives it understanding; and it cannot be rational to suppose, from any kind of human knowledge, that the organic forms and instincts of divine creations are derived from simple ova, or that matter creates form and intellect, in lieu of receiving its organic structure from intelligence or instinct; or from physiorganic forces of a higher order than those of matter, heat, and motion.

Some kinds of bricks and stones are more fit than other kinds of bricks or stones for certain architectural constructions; some kinds of ova are naturally and specifically more fit than other kinds of ova for the structure of certain kinds of organism: but neither simple stones nor simple ova are the generators or builders of architectural temples or of living organisms. The crossing of special races is known to have a passing influence in the multiplication of varieties; and organs modified by exercise, or faculties improved by education, are known to have hereditary influence for a time. But these, again, are just as rapidly lost by time as they were first acquired. It is supposed, however, by the Darwinian hypothesis, that these varieties of form and structure may be increased to any extent, and fixed for ever, or for countless ages, by some unknown accident; and further, that they may be newly moulded and transformed to any extent, until new varieties produce new species, genera, families, orders, and alliances, or even perhaps classes of new types. There is no reasonable ground in positive experience for this unlimited hypothesis. The human mind is necessary to construct houses and temples from simple stones; the Divine Mind is necessary to form the instincts which build up organisms from simple cells in the organic realms.

The reproduction or continuous principiation of species cannot be conceived by the human mind in any other way than that of the visible incarnation of invisible forms and forces already existing before the process of incubation commences in each special case, the form and structure being given to the special type of organism by these preexisting forces. The mating of animals and breeding are merely the occasional stimulants of incarnation, and not the procreating forces, beyond the simple fact of physical cooperation in furnishing a suitable kind of organic plasma in the form of eggs, or blood, or milk, as a basis of

plastic operations. The marked deviations from hereditary characters and features, in the offspring of species, forming *quasi* varieties at birth and throughout life, without any marked differences of conditions to promote such modifications by natural selection, shew this plainly; and such congenital deviations are not uncommon. There is, no doubt, a general hereditary transmission of typical form and feature to offspring in the perpetuation of species; but there is also frequent deviation from ancestral characteristics, not by the continuous effects of natural selection alone, and the crossing of breeds (for these acquired differences are as easily lost as gained by successive generations); but by inherent difference of character and physiognomy in the offspring at birth, and arising from natural varieties of instinct and character in individuals of all species, and especially of the human race. These deviations are much more conspicuous in moral than in physical features and dispositions. None more unlike the parents than the children, very often; and seldom are the characters alike in mental and instinctual peculiarities, apart from social education and position. And again, how unlike each other, brothers and sisters and near relations habitually are in character and disposition; and this not only in the human species, but in lower animals, as in dogs and horses. "Physical causation" alone can never account for these moral and instinctual deviations.

We may also note that structural deviations from the hereditary type appear and disappear at times in the same species, independently of natural selection. "More than once," says Peter Camper, quoted by Prof. Huxley, "have I met with more than six lumbar vertebræ in man. ......Once I found thirteen ribs and four lumbar vertebræ. Fallopius noted thirteen pairs of ribs and only four lumbar vertebræ; and Eustachius once found eleven dorsal

vertebræ and six lumbar vertebræ." In all these cases the vertebræ are constant in number, the ribs alone vary. The distribution of muscles and of blood-vessels is often various in the human body and also in the lower animals. These are not caused by "natural selection." They are the results of physiorganic forces inherent in the very principle of life and form which organises the whole body during embryonic evolution, from the germ, through all its metamorphic phases, to the final structure of the complex organism. Germs do not build themselves, nor do the bodies gradually developed from these germs build themselves. Coral reefs do not build themselves, nor do the fossil shells and bones embedded in the rocks, as once surmised by natural philosophers. Forms are given to all matter by living forces, which maintain those forms as long as they pervade them, and leave them to inevitable dissolution when abandoned by these forces.

Comte has been more circumspect than Darwin in adopting a modified view of Lamarck's hypothesis in his philosophy. "As for the gradual and slow improvement of human nature within narrow limits," he observes, "it seems to me impossible to reject altogether the principle proposed (with great exaggeration, however) by Lamarck, of the necessary influence of a homogeneous and continuous exercise in producing in every animal organism, and especially in man, an organic improvement susceptible of being established in the race after a sufficient persistence. If we take the best marked case, that of intellectual development, it seems to be unquestionable that there is a superior aptitude for mental combinations, independent of all culture, among highly civilised people; or, what comes to the same thing, an inferior aptitude among nations that are less advanced,—the average intellect of the members of those societies being taken for observation. The intellectual faculties are, it is true, more modi-

fied than the others by the social evolution; but then they have the smallest relative effect in the individual human constitution: so that we are authorised to infer from their amelioration a proportionate improvement in aptitudes that are more marked and equally exercised. In regard to morals particularly, I think it indisputable that the gradual development of humanity favours a growing preponderance of the noblest tendencies of our nature, as I hope to prove further on. The lower instincts continue to manifest themselves in modified action; but their less sustained and more repressed exercise must tend to debilitate them by degrees; and their increasing regulation certainly brings them into involuntary concurrence in the maintenance of a good social economy, and especially in the case of the least marked organisms, which constitute a vast majority. These two aspects of social evolution, then, the *development*, which brings after it the *improvement*, we may consider to be admitted facts."

Within these limits the development theory is quite legitimate, for we have the facts of the growth and renovation of strength in all the faculties and organs of the individual during natural life, and those of nations in the history of the race, to prove the possibility of such a law of progress in the future career of humanity; but we have no such facts to base a theory of metamorphic evolution upon with regard to the origin of species. Metamorphic evolution in the human fœtus is a different order of phenomenal succession and organisation from that of growth and renovation in that which has been once constituted as a typical creation, although the two orders of phenomena have many points in common. In the individual organism, however, metamorphic evolution in the fœtus precedes growth and development in the constituted organism; whereas, in the collective organism of society, growth in the individual faculties of the race

must precede organic changes in the constitution of society.

If we apply this view of the question to the natural selection theory, and admit the possibility of successive incarnations by the same individual souls of animals, we have still to inquire, in what manner an ape of the highest type learned to build himself a body and a mind of the human type, while he was formerly incarnated as a monkey? And if a monkey could not learn to act and think as a human being, during his existence as an ape, how could he learn after he had left this world and migrated to another? These questions must still wait for answers after all the ordinary facts have been accumulated in support of the natural selection hypothesis; whence we may infer that no solution can be given by that theory. We cannot easily get rid of the hypothesis of a Creator whichever view we take of the creation; and as most of us prefer this old hypothesis to that of physical causation, we may venture to believe that our Creator will not be easily dethroned by any other.

The conditions of physical life being much the same for all organic types inhabiting together the same region after birth, special physical conditions of incubation are required for special types of organism during the period of metamorphic evolution, and the exceptional conditions are furnished by the kind of substance which is peculiar to the ova and the blood of each particular species. We all know that physical constitutions differ greatly in different types, and sometimes not a little in the individuals of the same species; and we may thus easily conceive that the blood and ova of a carnivorous animal would not furnish the plastic conditions most suitable for the incarnation of an herbivorous or a frugivorous animal. Besides, the fact of this kind of incubative adaptation is patent in all species, and, therefore, we need not dwell

on its importance, as a part of natural economy, in the perpetuation of each species, by successive incarnations of preexisting forms and instincts from another world.

That invisible organic forms and forces should be modified and perfected by superhuman power in a higher world, and incarnated here by means of the perfected ova of existing species, or by means of newly-created forms of ova, is no doubt possible in nature, or we could not conceive the idea of a beginning of creation in the world. These are, however, very obscure questions, which men of special science may refuse to entertain, but we cannot avoid the question of whence come the organic and instinctual forces which form the body of the chick in the egg, and what becomes of these same forces when the body dies? Do they come from nowhere and return from whence they came? Are instinctual and mental forces merely heat and electricity, or matter and motion, converted, by incubation, into powers of emotion, thought, and understanding? Can we seriously avoid these questions by the superficial theory of "physical causation" and the "origin of species by natural selection"? The question is unavoidably mooted by the theory, however insufficient that theory may be, to give a satisfactory reply.

Our hypothesis is this, that the same organic force which sustains an organism throughout life, builds it up from the beginning of incubation, and abandons it at death. An invisible form incarnates itself by a succession of metamorphic evolutions in the plastic matter of the egg, during the period of incubation, and continues to renovate the organism from new supplies of elemental substance during life, as plastic matter is consumed by natural combustion, and ejected from the body by natural excretion.

The initial links of evidence are alone wanting to

prove the truth of this hypothesis, but rational evidence is not deficient on this point, and daily experience proves the rest. A physiological link is wanting in the evidence to prove the natural selection theory; and physical or visual evidence fails with us; but this kind of evidence being equally weak in both cases, the rational evidence is much more plentiful in one case than the other. The reader will decide which case, according to his own powers of appreciating different kinds of evidence.

As for "believing with Cuvier, that the possession of articulate speech is the grand distinctive character of man (whether it be absolutely peculiar to him or not)," as Professor Huxley says he does, "and finds it very easy to comprehend that some equally inconspicuous structural difference may have been the primary cause of the immeasurable and practically infinite divergence of the human from the Simian stirps:"—what does it amount to, but a disposition to believe, without good evidence, a favourite hypothesis, which leaves the question of creation, the pre-existence of instinctual forms and forces, and the periodical incarnations of these forces, exactly where it was before—in a state of mystery.

But the fairest way of dealing with an hypothesis of any kind is, to admit it, and then test it by practical and theoretical application. Admitting, then, the suggestive importance of all the known facts of structural modification by the influence of long-continued special training, and the hereditary transmission of acquired developments, either by ordinary mating, or by crossing breeds, we have still to ask how the first eggs were formed, of either low or high degree, and how the organic forms and instinctual forces became incarnated by incubation? In all known cases, organisms are derived from germs or ova, and these are formed by parent organisms; but germs of

some kind must have been created before organisms could be developed, or these must have been created from some other form of plastic substance *ab initio.* We must admit one of these alternatives: either germs preceded organisms, or these preceded germs. In the latter case, some one type, or several types, were first created, and all others are descended from them, with or without modification. If germs preceded organisms, what kind of germs were first created, and how many?

And, again, if one egg only, or a pair of eggs for the two sexes of one species, were first created, and other types have since been slowly developed from this one species, what organic form was first evolved from the incubation of this primitive egg, or pair of eggs? Was it a cryptogamic, or a phanerogamic, or a radiate, or a molluscan type? And, supposing it to have been the lowest type of the lowest realm, how did various types proceed by natural selection from this original organic form? And if, by the mere wandering of multitudes of individuals to different regions of the globe, where they had to struggle for the means of existence, and where the differences of climate and other conditions of life required continuous efforts of adaptation of structure to these varying conditions, how did all the different types inhabiting one region, in the same conditions of food and climate, proceed from the first multitude of individuals of one single species?

Or, again; admitting the original creation of a pair of eggs for the two sexes of one species, and either simultaneously or successively, in each geological period, a primitive couple of eggs for each of the four classes of the animal organic realms; say two eggs for the lowest class of radiata, mollusca, articulata, and vertebrata, and a similar beginning for all the other classes and for each class of plants; then, how came there to be so many

different species in each class, in any one region of the globe, where the varying conditions of existence are contemporaneously always much the same for all these hypothetically original species? And if, by countless ages and changes, these conditions of existence in each region, and the consequent modifications of structure by natural selection, were always favourable to continuous progression, how is it that many of the original species remained exactly stationary, while others were progressing all around them, under exactly the same changing conditions of existence? And how is it, that this marked arresting of development affected one great multitude at the earliest stage of evolution, and another at the second stage, while other multitudes were steadily progressing, however rapidly or slowly, from the second to the third, fourth, fifth, and highest stages of metamorphic development, under the influence of the very same changing conditions?

And how is it, that amidst these various conditions of organic and climatic adaptations and development, we find, at last, the herbivorous raindeer and the carnivorous fox inhabiting together the same arctic region of the globe at the same time, and under like conditions? The theory is really very difficult to work in application to known facts. And be it observed, also, that if we admit a dozen or more primitive eggs to have been created and incubated, either simultaneously, or successively in different ages of the world, it becomes almost puerile to limit the number of original ova to a dozen, or a hundred, or any other number short of that which includes all the species of extinct and living organisms. The original creation of one, or a dozen, or thousands, or millions of original and typical eggs, seems to be equally simple as a conception of creative power, either physical or mental, or both combined. Nor is the difficulty less,

supposing natural organisms to precede germs as parents of all living forms.

We need not dwell upon the practical difficulty of testing the hypothesis by an extensive and persistent course of transferring all species to different regions or conditions of food and climate, and crossing breeds in all possible directions, backwards and forwards, naturally or artificially; for this is what the partisans will have to do to prove its tenability; and that seems quite impossible. The origin of species is still a mystery unresolved, but, happily for us, the ascertainment of man's place in nature does not depend on the solution of that problem. Man's structural and physiological place is a matter of small importance compared with his sociological place in nature. We know that he is the highest special type, of the highest class, of the highest organic realm; we know that numerous gradations of rank in structure and mental endowments exist in the realm of vertebrata, to which man undoubtedly belongs; and to *suppose* that one type of vertebrate organism be merely the gradual transformation of another and an inferior species of the same general type, instead of *supposing* that many types were created at once, or independently, one after another, amounts to nothing but a difference of *suppositions*, where nothing is known of any kind of realmological creation, and very little of realmological permutation and progression. Man is certainly a vertebrate animal of the mammalian class, and whether he be more nearly allied to one brute creature or to another of the same class, is really of very small account. Man as a religious and a social being is the real question of importance; that of his position as a vertebrate animal is only a question of zoology. All animals have places in zoology; man alone, as a religious being, has a place in anthropology. Man has certainly the highest place in vertebrate ani-

mality; but he has still a higher place in epicosmic humanity.

Hypotheses are useful to stimulate investigation, and, while one lacks positive or rational evidence, as much as another, controversy should be modest in its tone, however earnest and enthusiastic it may be on either side. Where verifications are equally scarce, one hypothesis can hardly pretend to be more scientific than another.

Realmological creations are difficult to investigate on either "*physical causation*" or *mental causation* hypotheses; but sociological creations are easily observed, and in these we know that mental and instinctual causes are predominant. And now we come to the investigation of these very interesting human causes and effects in epicosmic nature.

Creative Humanity.—We have seen the natural divisions of the primary class of epicosmic creations in the organic and the inorganic realms; what, then, are class distinctions of the secondary or sociological creations of the epicosm? Are there three connective classes in this region of organic unity, as in the human body and the realms? When human beings are organised in society, what do they create, and how many kinds of sociological creation are there?

Human society must first be organised before it can create anything of sociological and epicosmological importance; for man, as an ignorant and unassociated savage, is nothing but a bimanal animal, a mammalian type of the vertebrate realm. His place in nature, according to Prof. Huxley, is with the apes; and strangely enough, where human beings live as animals or savages, they live in regions where the apes abound. Sociological man is therefore quite a different being from the mere bimanal savage. To enter the kingdom of heaven, which is the kingdom of law and order, peace and happiness, man

must be born again: the animal man must become a human being either in this world or the next. Heaven is not a place, but a state. "Heaven is within you," and may exist in any world.

Collective man, organised in society, has three classes of creation to produce,—an industrial class of forms and things, an artistic class of forms and symbols, and a scientific class of methods and sciences. The sociological or connective realms of creation, then, are of these three classes, *industrial*, *artistic*, and *scientific*. Nor are these human creations unimportant in sociological uses, when compared with superhuman creations; for the artificial locomotive, or steam horse, is much more fleet and powerful than the natural horse. It is not the human creations, however, but the human creators, which form the epicosmic secondary classes in connexion with the one main class. Industrial and commercial corporations and professions form one class, artistic corporations and professions another, scientific corporations and professions a third class; and the creations of these collective bodies in the epicosmic organism are analogous to the secretions and exuvial productions of the three classes of connective tissue in the human body. The creative societies, or collective organisations of humanity, are the connective classes, then, of epicosmic unity, which intermingle with all natural realms and govern them, as glandular excretors and adipous secretors regulate and govern the physiological operations of the animal economy.

Collectively organised humanity is a divine creation, in a certain sense, as much as individually organised animality. Religious and social economy are subject to perfect laws of order as much as structural and physiological economy. Man alone has never organised a nation in society without the aid of what has always been called Revelation. Religion is the true foundation of society.

Different societies have been organised by different religions professedly emanating from divine authority,—just as different types of animal organisation have been created by one superhuman power. One law of order differently illustrated, and more or less partially or perfectly developed, may be seen in all creations, and possibly in all religions. There is unity of composition in the plan of all organic types. The extinct antediluvian monsters were formed on the same general plan of structure as the most perfect modern species; and many of the carnivorous types are not less perfect as animals than the peaceful and harmless herbivorous species. Sanguinary religious revelation may have been just as natural and necessary in former ages as ferocious animals are at present. Human wisdom cannot pretend to reason with divine.

Whether or not one religion will eventually organise all nations and societies upon the earth, all other revelations and religions disappearing as the extinct races of animals have disappeared, leaving traces of their past existence only in the fossil remains of organic forms, is a question which we need not dwell upon, although it is suggestive of possible evolutions and metamorphic changes in the past and future developments of human society and civilisation. One general type of vertebrate organic unity is seen in nature, and to this organic type humanity belongs in physical structure and economy. Many sects are known in Christendom, but all belong to one religion. By natural selection man, to some extent, chooses his religion; but God alone reveals the truth in nature and in Revelation, which constitutes the law of order in the human mind. God creates the social and religious mind in man, then, by revealing truth; and man gradually gives his mind the form of truth by a succession of metamorphic evolutions, as he gives his body the form of organic unity by means of a succession of metamorphic changes in the process of gestation.

Olympian Jove was once the type of power in religion. The meek and lowly Prince of Peace is now the pattern of perfection in divine humanity. Gigantic reptiles armed for war, were once the leading types of power on earth amongst the animals; but now the humble form of man is the great type of power and progress in the world. The type of thundering war amongst the elements, and fierce dominion of the conquering classes over slaves, could never organise society in peaceful progress and development; but Christianity acknowledges no conquerors and slaves, all men are brethren. This alone, then, is the religion of truth, justice, peace, and progress, in its highest form. It only need be thoroughly received to render human beings capable of forming social and religious organisms, fit to live in peace, and thrive in powers of creative industry and happiness. Different sects of Christians are merely different types of Christian organisation, some relishing one form of truth and some another, as different constitutions relish some one kind of natural food, and some another. And here we may observe that Ecclesiasticism is not religion; peculiar creeds and dogmas are not essential truths; so that no particular sect or ecclesiastical establishment can pretend to the monopoly of Christian truth and infallible authority. Intolerant Puritanism amongst "Low Church" sectarians; despotic sacerdotalism amongst "High Church" sectarians; cold indifferentism amongst "Broad Church" sectarians, are almost equally removed from the simple faith of the meek and lowly Christian, "whose yoke is easy and whose burden is light."

Ecclesiastical organisation is no doubt essential to the church; but clerical corporations, seduced by inordinate love of temporalities and power, are not the best supports of healthy vigour in the church.

Scripture reveals God's moral truth, and nature his

organic laws, from which humanity may learn to organise society according to the perfect form. Revelation gives us a religion; science gives us an organic law; but we must inculcate religious truth, and study the organic law, before we can succeed in organising powerful and peaceful communities of human beings. Biology and sociology are now the sciences most wanted, in cooperation with religion, to enable man to organise society on firmer grounds, and these being rapidly developed in our time, may be expected to attain to something like a satisfactory status in a few more generations. Science alone can never organise society; religion must first draw men together in the bonds of unity and brotherhood, for science to have ground to work upon. And, moreover, religion must progress, or science cannot carry nations forward in the path of happiness. The human conscience must be gradually developed as well as the human intellect, for man to organise society on a progressive basis.

Ecclesiastical pretensions and assumptions may be retrogressive and obstructive in their influence, but these are not religious truth and charity; they are merely aberrations of human pride and passion clothed in brief authority; and in this point of view, they resemble all other kinds of arrogance in the abuse of power, which has either been delegated or usurped for a time. One of our great historians has not sufficiently marked this distinction between religion and ecclesiasticism, in stating that all human progress is the result of intellectual development alone, irrespective of moral and religious principles or progress. Science did not organise heathen society, Jewish society, Christian society. These have all been instituted by revelations from supernatural authority. Science could not abolish heathen, or Jewish, or Christian society; all it can possibly do, is to develope society, as far as it can be developed, on the principles of faith in

which it was first conceived and organised; just as culture and training may develope and improve a living organism of any kind, according to the natural type of that organism, be it high or low. Heathen society could not be developed beyond a certain point: Jewish society could not be developed beyond a certain very limited point; but Christian society, unobstructed by narrow ecclesiasticism, may be improved to any human extent; for in it all men are brothers, the sons of one heavenly Father, and coheirs of one divine salvation.

A much more perfect view of divine government is the evolutional history of humanity as given by the Rev. James E. Smith, in his *Divine Drama of History and Civilisation*, than that which is so well described by Buckle in his *History of Civilisation.* In the one, religion is contrasted with ecclesiastic forms and despotisms: in the other, priests and formularies are confounded with religion, as obstructive factors, in preventing human progress and the natural evolution of all science. Buckle's is an excellent history; but Smith's is still more excellent. The one describes ecclesiastical defects; the other shows God's providence in the revelation of new truths and new religions in past ages as the world required them. The book is little known, though published some ten years ago by Chapman and Hall.

Imperfect types of religious organism have been created for a time, to be succeeded by more perfect types, just as imperfect types of all the lower animals have been created in past ages, and superseded by new creations of a higher grade; until man was made to crown the whole, and Christ revealed as the incarnate God man, to crown humanity itself, and raise it from the darkness of animal existence to a glorious community with heavenly society.

This part of the genetic function of religion is even

recognised by those who deem all faith in the supernatural absurd, and teach that natural powers alone suffice for the production of all terrestrial phenomena. The French philosopher Monsieur Rénan, in the beginning of the fourth chapter of his *Life of Jesus*, lately published, makes the following remarks :—" Comme la terre refroidie ne permet plus de comprendre les phenomènes de la création primitive, parceque le feu qui la pénétrait s'est éteint : ainsi les explications réfléchies ont toujours quelque chose d'insuffisant, quant il s'agit d'appliquer nos timides procédés d'induction aux révolutions des époques créatrices qui ont décidé du sort de l'humanité." He goes on to explain the creation of the Christian religion on the hypothesis of a kind of redheat excitement in the Jewish nation at the time of the life of Christ, and the natural facility of new moulding the public mind in such a state, by any man of genius suited for the work. We need not dwell on the learned insufficiency of Monsieur Rénan's book, but observe that the gospel revealed a new religion to mankind, which was not then received by the " incandescent Hebrew nation ;" nor has it been accepted by their cool descendants since ; but has spread amongst the gentiles, and regenerated the whole western world.

And now the social man is born again in Christ, and has received the impress of a luminous spiritual nature ; he has only to be educated and developed in accordance with the higher law of his own spirit, in all the industrial, artistic, and scientific faculties with which he is endowed as a religious being. And these are the connective elements of epicosmic unity on our globe. Subordinate realms are more and more closely knit together and refined as human society advances in organic structure and development, improving nature in each realm, as the science of organic laws and the religious consciousness of

power and duty are awakened in humanity, cooperating with divinity in the government of our planet.

The creative-man's place in nature is one thing, then, and the animal-man's place another: not in bodily structure, but in mental and moral consciousness. Man is born a physical being, a bimanal mammal, but he becomes a man, by being born again of the spirit through the influence of religious revelation. The physical homo, as a child, is not a creative man; the physical man, as an adult, is not a social being, until his spiritual manhood be developed. The natural instincts and attractions of the physical homo, young or old, are carnal and destructive, and even hostile to those of the creative man: they dislike useful work of every kind, and take delight in plunder and disorder. The comic ditty of the schoolboy shows this plainly, in the following very graphic and well-known vernacular:

> "Multiplication is vexation,
> Division is as bad,
> The rule of three doth puzzle me,
> And practice drives me mad."

The adult bimanal has no such comic *naïveté*; but he might just as fitly say:

> Industrial work I love to shirk,
> Art-work is just as bad,
> The moral law doth puzzle me,
> And science drives me mad.

The whole of the criminal population of any civilised country, may be said to be in the lowest animal state; and few of us, in any class, can yet be said to be very far advanced in Christian manhood, or the love of useful and creative industry, art, science, and morality.

We need not dwell, however, upon these questions here, beyond what is required for a synoptic summary of the connective elements of epicosmic unity; and this may be done in the following table.

Connective Realms.	Z. Supernal Epicosmic Forces and Conditions.	Procreativo. Subcreative.
	Y. Epicosmological Infesta and Ingesta.	Procreative. Subcreative.
	X. Sociological Creations.	Procreative. Subcreative.
	X. Sociological Creative Powers.	Procreative class. Subcreative classes.
Organic Realms.	VII. Vertebrate Realm.	Viviparous Class. Oviparous classes.
	·7. Articulate Realm.	Articulate Class. Annulose classes.
	VI. Mollusca Realm.	Cephalophora Class. Acephalous classes.
	·6. Radiata Realm.	Vermiform Class. Radiate classes.
	V. Phanerogamic Realm.	Exogenous Class. Endogenous classes.
	·5. Cryptogamic Realm.	Acrogenic Class. Thallogenic classes.
Inorganic Realms.	IV. Elemental Realm.	Fixed Elements. Free elements.
	III. Geospheric Realm.	Geodynamic Class. Geostatic classes.
	·2. Reliquial Realm.	Realmological Class. Sociological classes.
	II. Thalattospheric Realm.	Synorganic Class. Inorganic classes.
	·1. Pluvial Realm.	Aquapluvial Class. Alteropluvial classes.
	I. Atmospheric Realm.	Synorganic Class. Inorganic classes.

From this table it is evident that one organic law rules in epicosmic, realmic, and individual complex unities; twelve epicosmic realms, twelve realmic alliances, and twelve systems in each organism, are the first natural distinctions; and connective classes of like character crown the scale of each of these organic units. The seven systems and five senses of the human body are manifestly natural distinctions, the seven primary and five secondary realms in epicosmic nature are equally distinct and undeniable; the only controverted point, then, of this law of natural distinction and association is that of

realmic unity and classification. Our seven alliances or twelve orders are not recognised by those who place the horse with pachyderms, and man with monkeys; and this is not a serious difficulty; for the most eminent zoologists differ from each other; some of them classing the horse apart, as we have done; and others placing man apart, as we have done.

The four natural classes of each realm have been already noticed, and a similar subdivision of the epicosmical connectives is requisite to make the parallel complete in all its bearings.

There are, then, three classes of epicosmical creative powers, in addition to the religious and political organic factors of human society, and these are the physical *industrial* class of human and animal activities; the instinctual and *artistic* class of human and animal activities; the mental and *scientific* class of human and animal activities. The roots of all these social powers are the spiritual or religious nature of the individual man, in connection with the *physical*, the *instinctual*, and the *mental* faculties of human nature. *Biology*, as a special science, deals with the physiology and psychology of the individual; *sociology* deals with the collective organism of society. These are special sciences to be investigated in detail, as each of the twelve realms of nature furnishes special fields of observation and organic science. Our present business being limited to a general view of epicosmology, does not include these sciences, but we shall give them due attention in their proper place.

In the synoptic table we distinguish the procreative sociological from the subcreative sociological factors of human society. The religious union of the sexes, and the political constitution of tribes, races or nations, belong to the first class, which is of primary importance, while the subcreative factors form three secondary classes of the connective or sociological realm of epicosmic unity.

The productions of these creative powers are the industrial creations of human society, the artistic creations, and the scientific creations. These results of human activity in the collective organism of society, are analogous to the excretions, secretions and exuviæ of the society of special organs in the body.

Another branch of sociological investigation pertaining to epicosmic unity, is analogous to that of the infesta, impregnata, recent ingesta, and healthy or unhealthy blood in connection with the body: and a fourth branch of the same question relates to the supernal forces and conditions of existence in all realms. These may all be tabulated in parallel with the corresponding factors of connective unity in the individual organism.

CONNECTIVE REALMS OF EPICOSMIC UNITY.

Z. Supernal Forces and Conditions.	H. *Embryonic incarnations and necrological destructions.*
	U. Climatic conditions of all realms.
	Ω. Food resources of all realms.
	O. Organic and vital forces in all realms.
Y. Epicosmic Infesta, etc.	H. *Impregnations of all realms.*
	U. Infesta and investa of all realms.
	Ω. Recent ingesta of all realms.
	O. Increase realised in all realms.
X. Epicosmic Creations, etc.	H. *Religious and political institutions.*
	U. Industrial creations.
	Ω. Artistic creations.
	O. Scientific creations.
W. Sociological Creators.	H. *Religious and political classes.*
	U. Industrial classes.
	Ω. Artistic classes.
	O. Scientific classes.

From this brief outline of what may be called the anatomy of an individual organism, such as that of the human body, a collective organism, such as that of the vertebrate realm, and a still more complex organism, such as that of epicosmic unity, we may proceed to a brief outline of the twelve realms as intermediate organisms or universes, illustrating the same organic laws of order,

number, weight, and measure, as the more limited organism of the human body, and the more important complex organism of the epicosmic world.

This will give us an outline of the anatomy of epicosmic unity, sufficient for one volume; but the more restricted questions of human physiology, psychology, and sociology, will each require a volume to complete our view of epicosmical biology; not to mention the more abstruse question of natural organic method.

THE VERTEBRATE ORGANIC REALM.

Synthetic Arrangement.—To find the natural laws of order and arrangement in the realm of vertebrata, and in other realms of what is called the "animal kingdom," has been the object of zoologists in all ages and all countries; and various plans have been suggested by different authors. Cuvier, De Blainville, Macleay, Van der Hœven, Owen, and many other eminent zoologists since Linnæus, have published each his own peculiar system of arrangement, based on what he deems the leading features of organic structure and diversity: but none of these authors agree in defining the principles of method, nor in the application of their views to natural divisions and alliances. They differ also in their views of metamorphic evolution and the origin of species. Buffon, Geoffroy St. Hilaire, Lamarck, and many other men of eminence in natural science, have theorised on the probable development and origin of all known species, including man himself, from a few simple germs of the lowest type and rank in nature. Cuvier and other philosophic minds have denied the rationality of such a theory, and maintained the common faith of Christians with regard to the distinct

creation of each type of organism. Not only are zoologists at war on questions of genetic origin, and the laws of vital evolution, but the rules of method and classification are still in a divergent state, even amongst men who are most eminent in science. Some lay stress on number as a key to natural divisions; others follow structural peculiarities, without regard to theories of number. One of these views need not exclude the other; but as yet, no leading principles have been universally recognised.

According to the Rev. Mr. Kirby, "the number *five*, assumed by Macleay as a basis of method consecrated in *nature*, ought to yield to the number *seven*, which is consecrated both in *nature* and in *scripture*." "Metaphysicians," he observes, "enumerate seven principal operations of the mind; musicians seven principal tones; and opticians seven primary colours. In scripture the abstract idea of this number is *completeness, fulness, perfection*." He believes that Mr. Macleay's *quinaries* may be resolvable into *septenaries* by more elaborate investigations; but we may now state that the number seven, though quite legitimate, is not the only numerical basis of natural distinctions in organic laws of method.

Richard Owen makes four primary divisions in his classification of mammalia. His distinctions of the *Lyencephalous, Lissencephalous, Gyrencephalous,* and *Archencephalous* subclasses, being known to all zoologists, need not be further noticed here. Many points of interest have been illustrated in these cerebral distinctions, but they do not form a valid system of divarication.

In lieu of the brain alone, we take the whole body as a type of unity, and the most obvious natural divisions of the organism, as a basis of numerical distinction. The number seven and the number five are there combined in the primary systems and the special organs of sensation. The seven systems are the vascular, the digestive, the

generative, the nervous, the osseous, the muscular, and the cutaneous: the five inosculatory senses or special organs of communication with the outward world, are the organs of taste, smell, touch, sight, and hearing, with the special organs of an opposite character belonging to the same series. The vascular system is the only one which differs, in our definition, from that which is commonly received; as we include air vessels, blood vessels, and water vessels, or the *respiratory*, the *circulatory*, and the *urinatory* apparatuses in one system, the functions of which are solely connected with the elaboration and the distribution of the blood.

This principle of natural division in a complex organism, suggests the idea of a similar numerical law of distinction in the parts of a collective organism, such as that of the mammalian class, to which the human type belongs. The collective ideal type may differ from the individual type in some minor points of structural development, such as those of a prehensile *trunk* in the elephant, a *marsupium* in the kangaroo, *cheek pouches* in monkeys and in rodents, *anal sacs* in the viverridæ, membranous appendages to the body and limbs of bats and flying squirrels, and other special points of conformation in certain species, hardly shown or only rudimentally developed in the highest individual organism, such as that of man: but these diversities may be embodied in a general formula of method, including all the individual varieties of type and form in vertebrate organic structure.

Let us see, then, how this law of order in organic grouping, as exemplified in the human body, may be applied to that collective organism of vertebrata, embodied in the class mammalia. Seven natural alliances may easily be placed in parallel with the seven systems of an individual body; not, perhaps, with any preconceived idea of analogy or correspondency, but merely as a

fact of natural organic subdivision and arrangement: thus,—

SEVEN ALLIANCES OF MAMMALIA.

1. The anthropine alliance.
2. The pithecine alliance.
3. The plantigradal alliance.
4. The digitigradal alliance.
5. The equine alliance.
6. The ruminant alliance.
7. The pachydermal alliance.

These alliances may seem at first imperfect, but a subdivision into natural orders will justify them. In the pithecine or quadrumanal alliance there are two orders; *i. e.,* monkeys and lemurs. In the plantigrade alliance, the ursine and marsupial orders. In the digitigrade alliance, the feline and canine orders; each containing subdivisions to be noticed presently. The anthropine or bimanal alliance forms but one order, and this contains but one family, and indeed one species only: and yet we place it in parallel with the whole nervous system, which ranks even higher than the other systems. The brain is the recognised organ of the mind in man, and man is the acknowledged head of the creation. The equine alliance also forms one order only, or one family. The ruminant alliance is much more complex, and may be naturally subdivided into *horned* and *hornless* orders. The pachydermal alliance properly so called, forms one order only; but the rodents are so nearly allied in many points of form and structure with the pachyderms, that we place them together in the same alliance.

Definitions and denominations.—We need not here discuss the question of proper names for these orders and alliances, as it is quite impracticable to give accurate definitions and denominations without creating new words which are objectionable. Monkeys are not quadrumanal, as their feet differ from their hands, although the four

extremities are equally prehensile organs. We cannot always follow Cuvier, who is the most widely known authority on this question. Linnæus classes man with monkeys in his order of primates. Cuvier separates the bimanal from the quadrumanal order. Huxley follows Linnæus, but separates cheiroptera from galeopithecus, which he places along with man as types of one order.

In natural divarication, the ambiguous types form links between contrasted congeneric orders and series. The galeopithecus forms the link between the bats, the roussettes, the lemurs, and the monkeys. The hyrax forms the link between the rodent and the pachyderm, having the external form of the hare with an internal structure akin to those of the tapirus and the rhinoceros. The giraffe seems to be a link between the horned and the hornless ruminants. The profeline wah, or panda, and the racoon are intermediate types between the feline and the canine digitigradal groups. The monotremata form a link between the ursine and marsupial plantigrades. We might, then, link the rodent and the pachydermal orders in a *hyraxine* alliance; the horned and the hornless ruminants in a *giraffial* alliance; the ursidæ, edentidæ, insectivoridæ, and marsupiata, in a *myrmecophagial* alliance; the feline and canine families in a *profeline* alliance; the cheiroptera and simia in a *galeopithecine* alliance. But some of these names would be objectionable. The seven alliances may be known by many different names, and those which seem most simple are, *pithecine, digitigradal, plantigradal, anthropine, equine, bovine,* and *porcine.* If we could venture to create new names for all the natural orders of mammalia, we should select some of the most striking characteristics in each type as a basis of denomination; and these are necessarily either structural, functional, or social. The latter is the most definite characteristic of man, as he is the only religious type of

vertebrata. Many other animals are gregarious and co-operative, but none are strictly sociological or rational.

The word bimanal is not a fit denomination in contrast with quadrumanal, as both types have two hands and two feet; the hands alone being markedly prehensile organs in man, while both hands and feet are almost equally prehensile in the monkeys. It would be difficult, however, to form perfectly appropriate names for any one family or series, exceptions being numerous in every group of common forms and features; and even where anomalous forms are fewer in proportion, the names would be a difficulty. Greek or Latin words alone, simple or compound, would be unfamiliar. Greek and Latin hybrid compounds would be more or less objectionable. Common words are insufficient for very accurate and numerous distinctions. The only practicable method seems to be a combination of the most widely known terms, irrespective of scientific fitness or unfitness.

Anthropos and pithekos may be taken as radical names for anthropine and pithecine alliances. Primatial may be substituted for quadrumanal; but that includes man with the monkeys, on the Linnæan plan, which is not a truly natural connexion. Natural divarication is the first necessity; appropriate denomination secondary. We attend to the most important, and leave the other to future improvements. The names which have the least definite allusion to particular points of structure are often the best adapted for general distinctions and denominations.

Twelve orders of Mammalia.—The seven alliances form a dozen orders of mammalia, which may be placed in parallel with the seven systems of the body and the five orders of the senses; to show that one law of primary distinction is common to the individual and the collective complex organisms of the vertebrate realm. This law of order is still further illustrated, if we place

the oviparous classes of vertebrata in parallel with the connective tissues of the individual body; and the general connective elements, which are common to both the individual and the realm, in like positions of relation and importance.

It is a curious fact, to say the least of it, that the most natural and obvious subdivisions of the human body and those of the whole realm of organisms to which that type belongs, should fall into one form of order, number, and arrangement so absolutely, that no human ingenuity could alter the distribution without doing violence to nature and to common sense; and this we verily believe to be the case. It proves that there is a common law of structure and diversity of form, in complex organisms, both individual and collective; and also that, by careful observation and analysis, the human mind may penetrate into the apparent mysteries of nature and understand her laws.

The following synopsis is exactly parallel with that of the human body, and further divisions proceed in the same manner.

SYNTHETICAL SYNOPSIS OF VERTEBRATE REALM.

Z. Dynamic endowments of vertebrata.
Y. Ingesta and infesta of vertebrata.
X. Exuviæ and secretions of vertebrata.
W. Oviparous classes of vertebrata.

G. Pithecine alliance of mammalia.	VII. Simial order. ·7. *Lemural order.*
F. Digitigrade alliance of mammalia.	VI. Canine order. ·6. *Feline order.*
E. Plantigrade alliance of mammalia.	V. Ursine order. ·5. *Marsupial order.*
D. Anthropine alliance of mammalia.	IV. Anthropine order.
C. Equine alliance of mammalia.	III. Equine order.

B. Ruminant alliance of mammalia.	·2. *Hornless order.* II. Horned order.
A. Hyraxine alliance of of mammalia.	·1. *Rodentine order.* I. Pachydermal order.

Organic Unity of Complex Organisms.—As the connective tissues of the human body run parallel with all the main tissues of the organs, so the oviparous classes of vertebrata run parallel with the mammalia in many points of structure and diversity of habits. In both cases the differences of type separate them into classes quite distinct from each other, while the law of distribution in the complex organisms causes the connective classes in one instance (glandular tissues in the body and birds in the realm) to run parallel with an order only, in one aspect, while it inosculates with four of the seven alliances, in another aspect. But these are questions of method which may be left for another place—the practical illustration will be most evident in the subdivisions of each class. To begin with the general connectives of the realm, under the letters W, X, Y, Z. We subdivide them, as in the parallel synopsis of the human body; each letter including four subordinate classes: thus—

Z. Dynamic forces of vertebrata.	H. *Different uterine supplies of food, etc.* U. Different climatic elements. Ω. Different sources of food. O. Different physiodynamic forces.
Y. Ingesta, etc., of vertebrata.	H. *Different incubations, etc., in classes.* U. Different infesta of classes. Ω. Difference of food in classes. O. Difference of blood in classes.
X. Exuviæ of vertebrata.	H. *Parturitional out-births.* U. Glandular excretions of vertebrata. Ω. Adiposerous secretions of vertebrata. O. Necrological exuviæ.
W. Oviparous classes of vertebrata.	H. *Extinct types of oviparous classes.* U. Birds. Ω. Reptiles. O. Fishes.

We need not dwell on the differences of type which distinguish birds, reptiles, and fishes; nor on the extinct

species of each of these three classes: and it is hardly necessary to observe that the secretions of birds differ from those of reptiles, and from those of fishes: the ova of each class are very different; the clothing secretions are also very different. The feathers of birds differ widely from the scales of fishes, and both differ from the hardened coverings of the reptile class. It is also by the fossils and petrifactions of extinct remains in each class, that the former existence of such types can now be recognised by geological investigations.

In each of the oviparous classes, the natural modes of incubation are different; and the vermin which infest birds are different from those which infest reptiles: these, again, are not the same as those which infest fishes. The nature of the food is not the same for every class; and the blood of fishes differs, to some extent, from that of reptiles, while that of birds is different from both.

The physiodynamic forces in fishes, reptiles, and birds are very different. They seek their food from different sources in many cases; and all climates are not equally suitable to every class and family. The uterine supplies of food or nourishment, during the period of incubation or gestation, are not the same in the oviparous classes, and they are still more different in the viviparous class.

We need not dwell on any of these points at present, as our only object is to show the order which is manifest in the relations and diversities of form and function in complex organisms, both individual and collective. The subdivisions of each class are not less marked illustrations of the law of unity, although the present state of knowledge in zoology is not as perfect as it should be, to enable us to class with accuracy, all the secondary subdivisions of each group or series. The following distinctions of series or families in each alliance, therefore, can only be deemed approximative, until further light has

been thrown upon the question by a full investigation. The parallels, however, are as curious as they are interesting, even where no positive analogy or correspondency are manifest at once, on superficial comparison.

Anomalous Types and Apparatus.—In the parallels between the seven systems of the body and the seven alliances of the mammalian class, the dominant character of each system and each class is easily discerned, in some, but not in others. The digestive system is apparently predominant in the canine and the feline species; while the generative peculiarities of structure and of habit are manifestly predominant characteristics of the plantigrade alliance. Bears hibernate during the period of gestation, and kangaroos replace placental by lacteal nutrition, not in part only, as other mammals do, but altogether, from a very early period of embryonic evolution. The pachydermal order of mammals is most remarkable for its development of the cutaneous system; and man is most conspicuous for his development of reason in connection with the brain and nerves. The other systems of the body are not so obviously predominant in the different alliances with which we place them in organic parallels, but there is no apparent cause for placing them otherwise in correspondency, as far as present knowledge of peculiarities dictates to us. We have in our own view numerous points of analogy in many cases of apparent obscurity, but they would seem far fetched without a most elaborate investigation of organic laws and modulations, which would be out of place in this scant outline of the system.

The natural subdivisions of each system and alliance are hardly less conspicuous in some series than those already noticed, and in others hardly less obscurely indicated. The distinctions are obvious enough, but the parallels are not so clearly analogous in any sense but

that of mere numerical arrangement. Still, we easily discern some points of peculiarity in every series, and where there is no direct analogy apparent, there are parallels of normal or abnormal characteristics in each case. For example, in the vascular system of the body there are three normal series and one ambiguous apparatus ; and so of the quadrumanal order of mammalia : thus—

SIMIAL ORDER OF PITHECINE ALLIANCE.

Vascular System.	H. *Umbilical series of blood-vessels in utero.*
	U. Respiratory series of air-vessels.
	O. Circulatory series of blood-vessels.
	Ω. Urinatory series of water-vessels.
Quadrumanal Order.	H. *Cheiropteridæ, or bats and roussettes.*
	U. Cebidæ, or American monkeys.
	O. Simiadæ, or old world monkeys.
	Ω. Ouistitidæ, or American marmosets.

In this parallel, the placental blood vessels are a temporary and supplementary series of the vascular system, and bats are an anomalous family of mammals, most markedly akin to monkeys and lemurs ; and as the umbilical vessels are links between the placental and the visceral blood vessels in the fœtus, so the galeopithecus forms a link between the bats and monkeys, showing that bats could not possibly be classed with any other than the pithecine alliance. The American monkeys are decidedly different, in many points of structure, from the old world monkeys, and the marmosets, according to Cuvier, form a series or a family distinct from cebidæ ; the latter have generally thirty-six teeth, while the marmosets have only thirty-two, like the proper monkey tribes. Some of the saki tribe of American monkeys might properly, perhaps, be classed with marmosets, but this we leave for future consideration.

Cuvier makes three primary distinctions of quadrumana : *monkeys, marmosets,* and *lemurs ;* placing near to them the bats, which have numerous affinities of struc-

ture with this order. Bats are evidently flying monkeys, and should be classed as such. Some of the species hibernate, and this is a prominent characteristic of the ursine order and of the generative system. Placental circulation continues only during uterine existence, and is therefore mainly connected with the generative function of gestation. Bats or hibernating flying monkeys seem to correspond to this ambiguous link between the vascular and generative systems in the body, and hence we place them in parallel with the placental circulatory series of vessels.

LEMURAL ORDER OF PITHECINE ALLIANCE.

Vascular Inosculators.	H. *Capillaries.* U. Nose. O. Lymphatics. Ω. Urethra.
Lemural Order.	H. *Myslemuridæ.* U. Indrisidæ. O. Lemuridæ. Ω. Cheiromydæ.

Isidore Geoffroy St. Hilaire divides the order of "primates" into four primary series: *simiadæ, lemuridæ, tarsidæ*, and *cheiromydæ*. This does not agree with that of Cuvier; and where such eminent zoologists cannot agree, we may conclude that much obscurity prevails in this department of natural science. All agree, however, in separating monkeys from lemurs, and that is our first distinction. Cuvier separates the marmosets from monkeys, and all zoologists distinguish American monkeys from the monkeys of the older continent. Marmosets are no doubt quite distinct from other platyrhina; but we think that the most obvious primary distinction of platyrhinal tribes is that of prehensile tails, and non-prehensile. This would place the saki and the brachyurus along with the ouistiti and the tamarin midas, in one series; thus forming two tribes, differing mainly in dentition; the proclividental tribe of nonprehensible tails, including the

saki and the brachyurus; the hapalian tribe of nonprehensible tails, the ouistitis, and the tamarins.

Zoologists have lately divided the indrisidæ from the lemuridæ of Isid. Geof. St. Hilaire, and with this distinction we agree. There are several species of very small mouse-like lemurs which may be classed with the *tarsidæ* of St. Hilaire, and by substituting the word *myslemuridæ* for tarsidæ we may form a natural division, including the species tarsier, gallago, microcebe, cheirogale, nycticebe, and loris, in one series. The inosculatory organs of ingress and egress to the different series of the vascular system, are not all of them, properly speaking, organs of sense, although there is no doubt a special function of sensation and monition in each one. The nose is the organ of the sense of smell and the passage of air to and from the lungs. The urethra is the special organ of sensation and micturition, in connection with the urinatory series. The lymphatics and the lacteals are the special organs for absorbing chyle from the digestive system and lymph from other parts of the body and conveying them into the blood vessels. The capillary vessels both absorb and exude the serum of the blood for purposes of circulation and nutrition. There are, then, four series of inosculatory organs in connection with the vascular system, and distinct from them as special organs of ingress, egress, absorption, and exchange. This inosculatory subsystem may be classed in four series, in parallel with four distinct series or families of lemurs: thus—

Vascular Inosculators.	H. *The capillary vessels: nutritional inosculators.*
	U. The nose: respiratory inosculator.
	O. The absorbents: circulatory inosculators.
	Ω. The urethra: urinatory inosculator.

Lemural Order.	H. *Myslemuridæ.*
	U. Indrisidæ.
	O. Lemuridæ.
	Ω. Cheiromydæ.

The different species of myslemuridæ (tarsidæ, etc.) have

been already named. The series of indrisidæ contains the long tailed indris, the short tailed indris, the avahis, and the propithecus. The series of lemuridæ contains the makilemur, the hapalemur, the lepilemur, and the perodicticus. The cheiromys is the only known species of that type; and thus in both the individual and the collective organisms, this series is simple and almost rudimentary. Linnæus placed both man and bats in his order of "primates," and some modern naturalists have followed his example in part; but do not include the bats in this order. We remove the *genus homo* from this unnatural alliance, and make the erectograde anthropine order distinct from the pedimanigrade pithecine alliance. The galeopithecus unites the bats, the lemurs, and the monkeys, in one natural alliance, as the hyrax unites the rodents and the pachyderms. The proper name for these alliances would be galeopithecine and hyracine, as all the families, and both the orders, meet respectively in the structural characteristics of these two representative types. Anyone who looks at the galeopithecus or flying lemur, may see at once the link between the bats, the lemurs, and the monkeys; and those who know the osteology of the hyrax, see at once the external form of a hare, combined with the internal structure of the tapirus and the rhinoceros. We may use the term hyracine alliance in one case, but pithecine is more simple than galeopithecine alliance, in the other.

Digitigrade alliance.—In the panda and the racoon, again, we have the link between the feline and the canine types, but the usual term of digitigrade alliance is better than a new term, such as pandine or procyonine alliance.

As the digestive gland ducts hold an intermediate rank between the digestive senses and the main organs of the alimentary canal, so the vessels of the umbilical cord hold an intermediate place between the vessels of placental

circulation in the mother's womb and those of general circulation in the body of the fœtus. The ambiguous organs of the human body, therefore, form a parallel with the anomalous types in the collective realm.

The main divisions of the digestive system, and those of the digitigrade alliance, may be placed together in the following parallel, or they may be classed together in consecutive order, instead of separate systems:

Digestive System.	H. *Temporary forms in utero.* U. The stomach. O. The small intestines. Ω. The large bowels.
Alimentary Inosculators.	H. *The digestive gland-ducts.* U. The mouth and œsophagus. O. The duodenum. Ω. The anus and rectum.
Canine Order.	H. *Extinct species of digitigrades.* U. Hyænidæ. O. Canidæ. Ω. Enhydridæ (seals and otters).
Feline Order.	H. *Profelidæ (procyon, nasua, ailurus, cercoleptes).* U. Felidæ. O. Viverridæ. Ω. Mustelidæ.

In consecutive order, the two systems may be thus arranged; and, in the body, the digestive series do occur in this order.

1 *The mouth* and œsophagus .	. 1. Felidæ.
2. Stomach . . .	. 2. Hyænidæ.
3. *The duodenum* . .	. 3. Viverridæ.
4. Salivary and hepatic gland-ducts	. 4. Profelidæ.
5. The small intestines .	. 5. Canidæ.
6. The large intestines .	. 6. Enhydridæ.
7. The anus and rectum .	. 7. Mustelidæ.

The first three series of digitigrades in this consecutive order of arrangement need not detain us, as they are already recognised by systematic zoologists. In the sixth series or family we place the common otter, the enhydra or sea otter, the seal and the walrus. The seventh series or the family of mustelidæ is well defined, and need not detain us; but we may observe that the transition from

the mustela to the otter has been too little noticed; and the easy gradation from the otter to the kalan or enhydra, from this to the seal, and from the seal to the walrus, has been hardly less neglected by zoologists. The latter type appears to be so far removed from that of common digitigrades, that it has not heretofore found a place in this alliance. There is a marked difference between the walrus and the dog; and so there is between the large bowel and the small intestine. In the fourth series we place the semiplantigrade aberrant genera of digitigrades—namely, *procyon, nasua, ailurus,* and *cercoleptes,* or racoons, coatis, the wah or panda, and the kinkajou; to which should be added the binturong.

Most of the feline order of this alliance have retractile claws; although the hunting cheetah amongst felines, and nearly all the mustelidæ, have unretractile claws. Some of the profelidæ, and all the series of the canine order, (hyenidæ, canidæ, enhydridæ,) have unretractile claws, and hunt their prey, instead of watching for it as the felines do. There are exceptions to this rule, however, in both orders, and it is difficult to find a general and uniform character of distinction without exceptions. All general distinctions must be taken, therefore, in a qualified sense. The words "feline" and "canine" belong properly to single groups, and are, perhaps, too special to denote their respective orders as well as the series; but new names would probably be less convenient.

A few words on natural organic method may not be out of place here, although we must defer all abstract questions of method for the present.

In the human body there are seven systems with distinct alliances of series in each system, and these series are of different orders in each alliance; but the methodical consideration of these systems and series may be varied in accordance with our own convenience in descriptive

arrangement. For instance, the inosculatory senses of the digestive system may either be considered separately, as a distinct order from the chief series of organs, or connectively, as they occur in consecutive union in the body. In nature, the mouth and œsophagus, the stomach, the duodenum, the small intestines, the large bowels, the rectum, and anus, succeed each other in natural series; while the digestive gland-ducts belong some to one series and some to another, but most conspicuously to the inosculatory senses, the mouth, and the duodenum. We may, then, describe the main series either in the contrasted order of voluntary and involuntary series, or in the consecutive order of mechanical arrangement; and the digestive gland-ducts may be also described either together, as a general hyper-series in contrast with the whole digestive system, or connectively as they occur in mechanical association.

The same diversity of descriptive method may be applied also to the digitigrade alliance of mammalia placed in parallel with the digestive system, and it may require much careful study to form the parallels of all the series in natural organic correspondency. For instance, in lieu of placing them in consecutive parallels as felidæ, hyænidæ, viverridæ, canidæ, enhydridæ, mustelidæ, and profelidæ, they might, perhaps, be thus arranged with equal propriety,—canidæ, hyenidæ, viverridæ, profelidæ, felidæ, enhydridæ, mustelidæ. The latter view involves a corresponding change in the raptorial alliance of birds which does not seem to be as natural. We do not profess to give a perfect application of the law of natural correspondency in our organic parallels, but a sufficient approximation to illustrate the general law, leaving all questions of doubtful accuracy to be discussed in a more elaborate part of our inquiry, when the principles of organic method are considered in the abstract, and apart from special applications.

The ursine order.—In this order we have a like difficulty with the name, as three distinct families are included in one primary division, namely, *ursidæ*, *edentidæ*, and *insectivoridæ*. The latter have been classed as distinct orders, but they are only entitled to the rank of families or series.

Nearly all marsupial animals are more or less plantigrade; and as the ursine order here described are carnivorous, insectivorous, frugivorous, and omnivorous, they are just as well entitled to rank as a sub-class as the non-placental marsupiata, which have had this honour mainly on account of their diverse habits of feeding, which were placed in parallel with those of all placental types. Marsupial types are merely aberrant forms of plantigrade mammalia, neither more numerous in species nor diversified in structure than the rodents which rank only as an order.

Plantigrade alliance.—The plantigrade alliance is placed in parallel with the generative system of the body, and the following series in each are obviously natural :

Generative System.	H. *Wolfian bodies and transitory forms in utero.*
	U. Ovaries and testes.
	O. Uterus and vesiculæ seminales.
	Ω. Mammæ in both sexes.
Generative Inosculators.	H. *Marsupium in kangaroos.*
	U. Oviducts and epididymus.
	O. Cervix uteri and ejaculators.
	Ω. Nipples in both sexes.
Ursine Order.	H. *Extinct types of the alliance.*
	U. Ursidæ.
	O. Edentidæ.
	Ω. Insectivoridæ.
Marsupial Order.	H. *Monotremata.*
	U. Urso-marsupidæ.
	O. Edento-marsupidæ.
	Ω. Insectivo-marsupidæ.

The series in these orders are quite distinct and natural, but the names are more or less defective. The bears are a very distinct family, and so are the insectivoridæ (moles, shrews, hedgehogs, etc.) The *edentidæ* (including sloths,

anteaters, armadillos, pangolins, etc.) are also a recognised family, although the name is somewhat inappropriate, as all the species are not devoid of teeth. The same may be said of *edento-marsupidæ*, but a collateral name seems preferable to one of no definite meaning. In the marsupial order the different series are as well marked as in the ursine order. Dasyurina, didelphina, phalangistina, phascolomys, and phascolarctos, are evidently ursiform marsupials. Kangaroos, kangaroo rats, bandicoots, and chæropus ecaudatus, form clearly a natural series, which may be placed (in contrast with the edentidæ) as a distinct family of the marsupial order. Some of the smaller types of marsupiata, which are mostly insectivorous, although not hitherto recognised as a distinct family, might very properly be classed in a distinct series responding to the insectivoridæ of the ursine order. In this family of *micro-marsupidæ* (or insectivo-marsupidæ) we place such species as those of dromicia, tarsipes, didelphia murina, phascogale, etc. The monotremata, containing the platypus and the echidna, have always been recognised as a distinct family or series. Extinct types of this alliance are more or less numerous in each series. Ursus spelæus, megatherium, and many other extinct types of both the ursine and marsupial orders, are too well known to need enumeration.

And here we might observe that the monotremata form a natural link between the two orders of this alliance, being at once akin to hedgehogs in external form, and to marsupial animals in osteological structure.

Anthropine alliance.—This contains but one order, that of man; and this order contains but one family. There are several varieties of the animal or physical man, and that is all we have to consider in arranging the different alliances of the mammalian class. Man as an animal is one thing, man as a human being is another. There are

but few races of the bimanal series that have yet been somewhat developed as rational and social beings. As a vertebrate animal, man is distinguished by a very slight diversity of form compared with that of the anthropoïd ape, the dog, the bear, or the pig; but as a moral being he is quite distinct, whenever he attains to the dignity of that estate. It is not, however, as a human being we have now to deal with the bimanal type, but as an order of peculiar structure in the mammalian class. We have had elsewhere to deal with man as the head of the creation.

In organic parallels of structure man claims the highest place in the development of brain and nerves. The natural divisions of the nervous system, therefore, should be those of the human races in a purely physical point of view. The nervous system may be variously subdivided, according to the regional distribution or the functional uses of the different parts. In form and function nerves resemble telegraphic wires, communicating some kind of radiatory influence from the body to the mind, and from the mind to every part of the body; and hence they have been classed as sensor and motor nerves. This gives us only two distinctions.

Conductor nerves, sensor and motor, are composed of a soft, white substance terminating in the cerebrospinal centres, and in the peripheral or ganglionic extremities, amidst a gelatinous vesicular grey substance which seems to be the articular or connecting medium between the physical substance of the body and the supersensuous forces of the soul. The distinction of nervous matter, then, into white and grey substances, gives us another twofold distinction. It seems to be as difficult to find complexity of form and structure in the nervous system as in the races of mankind. In either case the whole system or alliance would appear to consist of one order

only or one series; and yet the nerves communicate with every part of the body, influencing it in a peculiar manner, according to the difference of function in each tissue and organ. The races of mankind are also very much diversified in minor points of form and feature, though very faintly marked in varieties of organic structure. Differences of colour and complexion are numerous but insignificant, and other diversities of race are hardly more important. There is then, but one family of nerves, slightly diversified in form and function for each tissue and each organ in the body; one family of men, slightly diversified in form and feature for each special region and society upon the globe. And yet the nervous system in the body is not less complete, nor is it less distinct and general than any other system; nor is the erectograde bimanal type of vertebrata less distinct and general, as an alliance, than the more complex alliances of vertebrata. The most complete geographical distinctions of mankind are those of the European, African, the Asian, Australasian, and the American divisions of the globe; and these may be severally subdivided into tropical, genial, temperate, and variable clime races. The tropical races of mankind differ somewhat from those inhabiting the temperate zone; and those of an intermediate latitude differ, again, a little from the tropical and the temperate clime races; and possibly we may detect some difference from all the others in the races which inhabit colder regions; but these are not very marked distinctions, such as those which are observed in different families of the inferior animals. The nerves may differ also slightly in their structure and peculiar modes of action, where the different organs have peculiar functions influenced by the nerves. The mind is conscious of sensor and motor action in some parts of the body, unconscious of both in other parts, while there is a third kind of action which is both con-

scious and involuntary. There are, then, voluntary, involuntary, and spontaneous or reflex actions in the body; autocratic, automatic, and autotelic actions; conscious, unconscious, and mixed; the latter kind being both conscious and involuntary, and thence called autotelic (*auto*, self, and *teleios*, perfect or complete). Some of the human races seem conscious of moral dignity and responsibility, while others seem entirely unconscious of either; and a third variety may claim a place between these two, as being conscious of right and wrong, but too impulsive to control their appetites and passions. These, however, are moral more than physical distinctions, although the races may be physically organised with such peculiarities of frame as may obstruct or favour the development of moral and of mental powers. The inferior races, in that case, will probably die out, eventually, to be supplanted in each savage region of the globe by the moral and the intellectual races of mankind; or it may be that these backward races may remain as free servants and intermediate agents between the higher human races and the animal kingdom, as the conductor nerves are intermediate agents between the central and peripheral vesicular grey substance which connects the physical organs of the body with the supersensuous forces of the soul. Meanwhile we may form a general distinction between the white conductor-nerves and the ganglionic substance, and a similar distinction between the inferior and the superior races of humanity.

There are transitory forms of nerves, no doubt, during the uterine period of existence; but we know of no extinct races of men as yet, although several known races seem to be threatened with extinction as civilisation spreads without being able to absorb them. This may suggest the idea that man is not yet born collectively into a world of perfect social form and light, which is evident enough

from actual facts, without analogy or philosophic inference.

CONFLICTING THEORIES OF ZOOLOGICAL CLASSIFICATION.—Mr. Huxley connects the evidence of "man's place in nature," with two distinct theories: the Linnæan theory of classification, and the Darwinian theory of the origin and transmutation of species; neither of which are sufficient, even with the corrections of Cuvier and other eminent zoologists for the one, nor with the limitations of Mr. Huxley for the other. There is, in fact, no valid system of divarication yet; for all the leading naturalists of the present and past ages, differ in their views of natural distinctions and arrangement. Two special works on this subject have been written by two of the most eminent zoologists, within the last few years, and neither of them have given a satisfactory explanation, either of the principles of agreement and subordination in structural diversities of form, or in the psychological diversities of instinct and habits, in similar types of organism. Instead of looking first for the natural system of coordination in the human body, and then for the most evident line of subordination in the seven great systems of any given type of organism, some have taken one set of organs as the most prominent characteristic of a certain type, and some another. If we glance at the class mammalia alone, the primary, secondary, tertiary, and nearly all general divisions above those of genera and species, differ in Linnæus's, Cuvier's, Owen's, and Agassiz's arrangements; not to mention at least a dozen other systems, bearing the names of Aristotle, Lamarck, Vicq d'Azyr, De Blainville, Milne-Edwards, Leuckart, Oken, Kieser, Bojanus, Spix, Huschke, Carus, Vander Hœven, MacLeay, Swainson, etc. All these authors differ more or less in their ideas of what should be the natural limitation of classes, orders, families, tribes, and genera; agreeing only or mainly in those of distinct species.

It would be tedious to analyse their leading views of classification on structural, embryological, and so-called "philosophical principles;" but we may refer the reader to an *Essay on Classification* by Agassiz, and to Richard Owen's work *On the Classification and Geographical Distribution of the Mammalia*, where all these different systems are explained and criticised.

The distinctions of species and varieties, tribes and families, are mostly correct in all these writers, because structure and habit alone are sufficient for such limitations and connections. There is also little difference in the arrangement of classes; but orders and alliances are nowhere fixed on satisfactory principles. One writer dwells on one set of structural features, as a basis for the natural aggregation of different groups, while another holds a different view, and gives a different arrangement. Our views are warranted in some degree by all the leading naturalists; for where we differ from one, we agree with another, either entirely or proximately. None but Linnæus places the bats with monkeys, nor does he place whales with pachyderms, in close alliance; but all acknowledge the affinities, and point them out.

We have a perfect type of order in the human body, from the highest to the lowest limits of divarication. Here we find classes and subclasses, alliances and orders, families and tribes, genera and species: and as these divisions are found in all organic bodies, it is easy to perceive which set of features is predominant in any type of organism, or group of organisms.

This alone is not sufficient for a parallel between the individual body and a collective class; but it is enough for minor limitations and connections. We could not know from structure alone, that the mammary glands of the human body, especially in man, belong to the generative system or alliance of organs; but we know it from

their functional characteristics. We could not tell from structure alone that the kidneys and the lungs belong to the vascular system; but we know it is so from functional characteristics. In fact, the kidneys never have been, that we know of, classed as an apparatus pertaining exclusively to the vascular alliance, until we ourselves observed the natural order; for the usual method has always been to class the kidneys with the generative system, as a "genito-urinary apparatus." Structural and vicinal alliance have been dwelt upon, instead of functional alliance and cooperation. From this one oversight alone, the human mind had not perceived that there were seven complete systems or alliances of organs in the human body; and that "order, number, weight, and measure," could be analysed and found conspicuously together in the microcosm or little world of human nature, more easily than in the macrocosm or planetary universe.

Organic Associations.—And here we may observe that there are four kinds of association and connection in the organs of the body: namely, a *conjugative* association of series in each system; a *cooperative* association of systems in the same alliance, and of alliances in the same mechanism; a *vicinal* association of different series, with or without direct functional cooperation; and a *federative* association of different classes of organs and tissues in the same organism: not to mention *inosculative* functions and connections between the ambiguous links of one system and the main series or families of a different system in the body. There is vicinal association between the urinatory apparatus of the vascular system, and the genital apparatus of the generative system; but there is not conjugative association in reproductive functions. There is cooperative association between the muscular and the osseous systems; but there is no conjugative

association of structure and function, as between the costal, the vertebral, and the limb series of bones. There is federative association between all the systems of the body ; immediate coöperation between the muscular and osseous systems ; the digestive and the vascular systems ; vicinal association between the senses of several different systems, as the eyes and nose, mouth and ears ; but conjugative or intimate associations exist only between different series pertaining to one system or alliance.

These very different kinds of structural and functional arrangement of groups in the human body, give us an idea of like differences in the structural and functional diversities of groups in the collective body of a realm, or of a class of organisms in nature ; and as bones are quite distinct from muscles with which they are structurally connected in the individual body, so horses are distinct from pigs and horned cattle, although they all have hoofs, and may be classed together as "ungulata," just as the muscles and the bones may be classed together in a complex motorial alliance. The glands and ducts of the digestive system are structurally not unlike those of the generative system ; and the teeth of the carnivorous dogs are much like those of the carnivorous bear ; but the functional relations of digestive and generative glands are quite distinct ; and so the general habits, form, and structure of the digitigrade alliance are very different from those of the plantigrade alliance.

In the human body there is a natural distinction to be made between primary and secondary classes of organs and tissues ; and in the vertebrate realm, a similar distinction between viviparous and oviparous classes of animals. In the individual body again, there is a primary distinction made by Bichat, between the organic and the relational systems ; and this will be more complete by including the generative system as a part of the organic

mechanism ; although it was not so admitted by Bichat. In these two mechanisms there is close connection on the one hand between the digestive and the vascular systems; and, on the other, between the muscular and the osseous systems ; and these connections might induce some minds to form one alliance for each of these double systems. That, however, would clash with the simplicity of the generative system in one case, and with those of the nervous and cutaneous systems in the other. It is much more simple and natural to form three organic systems or alliances, and four relational systems : thus forming seven alliances or parallel divisions, irrespective of the closer structural connections between some of these alliances than others. On the other plan we should first have two divisions, and three divisions or five general distinctions, two of which would then have to be alone subdivided, before we could proceed with natural and parallel subdivisions in different series of each septenary order. There would be a generative system and a nutritional alliance in the organic mechanism ; a nervous system, a motorial alliance, and a cutaneous system, in the relational mechanism. These five divisions could not be subdivided equally, as three of them would contain four series in each, while the other two would each contain eight similar subdivisions. The only natural system of division, in a complex organism, a realmic unity, and an epicosmic unity, contains seven primary and five secondary systems, the seven alliances being equal to twelve orders. These have been already named in the human body and the epicosm and need not be repeated. We may observe, however, that zoologists have not been conscious of a like arrangement in the different orders, families, and tribes of animals in the class mammalia : and that they have formed their groups on the most superficial view of structural alliances. In Cuvier's system

the first three divisions of mammalia are *unguiculata*, *ungulata*, and *mutilata*. These have no real importance in organic views of order, and their immediate subdivisions are unequal and without significance. *Bimana*, *quadrumana*, *carnaria*. *Marsupialia*, with three kinds of teeth ; *rodentia*, without canine teeth ; and *edentata*, without incisor teeth ; are the six primary subdivisions of his unguiculata ; and these divarications depend upon the teeth alone, or mainly. We admit a distinction between "bimana and quadrumana," which Linnæus and others class together in one order as "primates"; we deem *carnaria* a very heterogeneous order, and quite unnatural. *Cheiroptera* and insectivora are natural groups, but they belong to very different orders, and cannot be brought together, merely because they are insectivorous. The *carnivora* include the bear, the dog, and the seal, in one group, and this again is quite unnatural, on every other ground but that of teeth, which is not of first importance. The marsupialia and the rodentia are natural orders, but their highest claims of connexion or alliance are not noticed in this system of arrangement. Their proper order and relations have been given in our own synopsis.

Again, the *ungulata* of Cuvier are subdivided into pachydermata and ruminantia : the second is a very natural alliance, but the first is not : for the horse is not congeneric with the hog, as the latter evidently is with the rhinoceros and with the elephants. This has been admitted by Vicq d'Azyr and Lamarck, who give the horse a separate place in the chief divisions of mammalia. And Cuvier himself, in his first system, published in 1789, placed the horse in a separate order; the elephant also. His ten orders were *quadrumanes*, *carnassiers*, *rongeurs*, *édentés*, *elephants*, *pachydermes*, *solipedes*, *amphibies*, *cétacés*. In altering this system he made some improvements and some mistakes ; for while he removed the seals,

very properly, from the dugongs, he removed the insectivora from the plantigrades erroneously; and he placed the horse with pachyderms, as Linnæus had done before. He was right in abandoning Vicq d'Azyr's order of *empetrés* (*amphibies*), but wrong in abandoning his order of "*solipedes*," merely because it contains only one genus. He was right in placing cetacea and sirenia together in one group: though not in giving it so high a rank.

The *mutilata* form a natural group, of very limited range, in parallel with ungulata and unguiculata, and not at all entitled to hold rank in any such parallel division. The primary distinctions, then, are useless in this last arrangement, published in 1830; while the secondary orders are unequal in importance, and some of them unnatural. The "families," so called, are natural groups in all cases but one,—that of the "carnivora," in which the dog is classed with the bear: but even here, distinct orders are placed side by side with minor groups or families. And yet the Cuverian system is, perhaps, as near as any other to the natural system. It has been very slightly modified in useless parts by Richard Owen, without being much improved in all the secondary groups. The orders and the families of Owen are, however, an improvement upon those of Cuvier.

In all the various systems, structural characteristics have been alone considered as features of distinction, while functional characteristics have been more or less disregarded. In nature, sometimes one of these, and sometimes the other, may be most evident; and both are equally important, in the distinction of realms, classes, alliances, orders, families and species. We have one principle of divarication in the human body, alternating on these two main characteristics: structural and functional: and the same principle of unity and dual alternation applies to the natural divisions of a realm. Natu-

ralists have no unitary principle of order, and only the one class of structural characteristics to rely upon. Cuvier's designations of bimana and quadrumana have been blamed on structural grounds of distinction. Natural delineations are one thing; names and definitions are another. The names of our divisions are not perfectly accurate, but the distinctions are quite natural. We have been obliged to give old names to new divisions, but that is unimportant.

The question of structural and functional alliance, then, has been very imperfectly dealt with by naturalists, who form as many different systems as there are leading writers on the subject. Mr. Huxley adopts the Linnæan order of "primates," and rejects Cuvier's separation of the genus *homo* from that of *troglodytes* in different orders. On structural grounds alone, he may be warranted in this; as Cuvier, regarding hoofs alone, may form a strange subclass of *ungulata;* and regarding claws alone, another subclass of *unguiculata;* regarding teeth alone, he may form a heterogeneous family of *carnivora;* regarding food alone, a heterogeneous order of carnaria; but none of these are truly natural divarications. We attach no importance, then, to the Huxleyan "evidence of man's place in nature" on structural grounds alone; nor to the Darwinian theory of transmutation, which suggests that man is derived from the ape, by the prolonged influence of "natural selection" on structural development.

There are three distinct grounds of comparison between man and monkeys; and these are *structural, physiological,* and *sociological.* Mr. Huxley admits the physiological link to be wanting, as no hybrids have ever been known, but says nothing of the sociological hiatus, which is much more important. Not to dwell on the last factor of distinction, we may observe that naturalists have not yet constructed an organic method which sufficiently con-

trasts physiological with structural characteristics. They have no definite plan of distinguishing races, species, tribes, families, and affinities, on physiological grounds and in contrast with alliances, orders, series, genera, and sectional divisions on structural grounds, as illustrated in our arrangement of mammalia.

Physiological Affinities.—Where different species produce hybrids, there is hesitation with regard to proper definitions; some contend that reproductive affinities should form the proper limits of a species; others maintain that the horse and the ass are distinct species, although they may give birth to hybrids. The fact is, we do not know from experience, where the lines of hybrid generation are drawn in nature between different tribes and families. There is a very marked affinity of structure and of habits between the three families of mustellidæ, viverridæ, and felidæ; nor does it seem to be impossible that some varieties of any one of these might breed with some varieties pertaining to the others: the wild cat, for instance, with the delungdung; or the ichneumon with the polecat or the weasel. The cats, the lynxes, and the pards are different tribes of felidæ; and some of these may or may not be artificially capable of breeding hybrids. The lion, the tiger, and the leopard are different species of one tribe, and these are known to produce hybrids. Different races of the same species easily breed together, by artificial training, although seldom known to seek each other in a state of nature.

The word species cannot well be limited to reproductive affinities, as these extend through several gradations of structural diversity. Races, species, tribes, families, and affinities, seem necessary definitions between the possible, if not the actually known limits of hybrid generation; for the African and the Asiatic lions are different races of one species; the lion, the tiger, and the leopard

are different species of one tribe; the tribe of pards are distinct from those of cats and lynxes; these three tribes belong to one family; and the three families of felidæ, viverridæ, and mustellidæ belong to one order of structural, and, perhaps, of physiological affinity.

All parts of the human body have some degree of intimate relation to all other parts of the same organism, and all the types of one realm or class have some degree of close relation to all other types of the same class; so that natural distinctions are not always very sharp, though very definite. Where structural differences are not very marked, we must observe physiological differences as lines of distinction, and especially in separating man from the anthropoïd apes, where the latter are more evident than the former, and where both are further differentiated by the unique sociological characteristics. Does Mr. Huxley include bats and sloths as "primates"?

"Natural selection" theories and "physical causation" philosophy may bring to light many interesting facts; but they cannot fairly claim more than is due to them in the ranks of natural science. Enough of this digression. Let us return to the question of organic parallels between the human body and the realm of vertebrata.

Equine alliance.—The osseous system is more easily divided into series than the nerves, although the bones are not diversified in structure as much as other organs. The equine alliance is also less diversified than any other except that of man. In the osseous system we have a central series of cranio-vertebral bones, a medial series of costal bones, and an external series of limbs. In the equine alliance there are asses, zebras, and horses, slightly differing from each other, but remaining distinct as types in nature when not artificially induced to breed promiscuously. The cartilages of articulation form a kind of link in the osseous system, and the sterile hybrids of the equine

types may rank as a kind of link between the otherwise distinct families. From this point of view we have the following parallel between the osseous system and the solipede alliance :

Osseous System.	H. *Articular cartilage hyper-series.*
	U. Limb-series of bones.
	Ω. Costal series of bones.
	O. Cranio-vertebral series of bones.
Solipede Alliance.	H. *Hybrids of different races.*
	U. Horses of different races.
	Ω. Zebras of different races.
	O. Asses of different races.

The transitory forms of bones in the course of embryonic evolution may be represented by extinct species of the equine type, though very few, or only one, the *hippotherium,* may yet have been discovered.

Ruminant Alliance.—The most conspicuous natural distinction in the muscular system is that of muscles and tendons; the most contrasted form of animal belonging to the ruminant alliance is that of horned and hornless cattle. Hence we have a general and inosculatory system in one case; and a horned with a hornless order in the other, as in the following parallel,—

Contractile Muscular System.	H. *Cutimotor series and transitory forms.*
	U. Epicosto-motor series of muscles (limbs).
	Ω. Costo-motor series of muscles.
	O. Vertebro-motor series of muscles.
Vibratorial or Tensorial System.	H. Tendons of cutimotor muscles.
	U. Tendons of ears; organ of hearing.
	Ω. Tendons of face and glottis; vocal organ, etc.
	O. Tendons of general system; muscular sense.
Horned Ruminants.	H. *Giraffidæ and extinct types.*
	U. Cervidæ.
	Ω. Antilocapridæ.
	O. Bovidæ.
Hornless Ruminants.	H. *Chevrotidæ.*
	U. Moschidæ.
	Ω. Auchenidæ.
	O. Camelidæ.

The organs of hearing, the organs of voice, and what is

called the "muscular sense," are inosculatory in connexion with the general contractile and tensorial or vibratory osseo-muscular systems. Music, language, the acrobatic and the mimic or dramatic arts, are mainly concomitant with these peculiar senses of the physical organism. We know of no marked analogy between these arts and the endowments of the animals belonging to the ruminant alliance; but it is not impossible that something of the kind may yet remain to be discovered; for the most intelligent response we ever saw made by a herd of animals to the call of one of their own species, was made to the appeal of a cow (which had just dropped a calf in a lonely spot) by the herd which was grazing far away in all directions, among hills and dales, out of sight, half a mile or more away from the place in which the scene occurred. From all the hills and hollows within hearing distance they came trooping fast and earnestly, with ears erect and eyes expressive of unusual excitement and intelligence, to aid the mother in her new embarrassment; and all which could come near enough, seemed anxious to lick the new-born calf, and cleanse it from the slime in which it was enveloped, until by degrees the warmth and stimulation of the process seemed to give new life to the young creature, which was enabled, within an hour or so, to rise and walk a few short paces. The peasants came and interfered too soon for our amusement, with this natural scene of animal coöperation and good feeling; for which meddling we did not feel disposed to thank them at the time. Horses and cattle are probably more sensitive to musical and vocal sounds than other tribes of the mammalian class; but this has not been verified to any great extent, as far as we know of any such experiments.

Several extinct species of ruminants have been discovered, but not as many as in some other orders of mammalia. Perhaps the porcine or the pachydermal order

furnishes the largest number of extinct species, and these we place in parallel with the transitory forms of the cutaneous system of the fœtus.

Pachydermal Order.—The skin of the human body, or that of any other mammal, seems not so obviously subdivided into series as the other systems; but a little observation shews us that it is. The outward skin is markedly distinct from mucous membranes; and this gives a first division into an external skin, and an inosculatory system of internal skin: and, as in the muscular system we had the vibratory organs of sense along with the tendons of the muscles in the osseo-muscular inosculatory system, so in the cutaneous system we find the special organs of what may be called the radiatory senses, of sight, touch, and temperature, connected with the mucous membranes and the skin. The subdivisions of the outward skin most naturally follow those of the external frame, as indicated by the muscles and the bones; and thus we have two systems in this case as in the last. The parallel divisions of the pachydermal and the rodent orders naturally also correspond to those of the cutaneous systems:

Cutaneous System.	H. *Transitory forms in utero (chorion), cutaneous appendages, of collago, bats, squirrels, etc.*
	U. Skin of the limbs.
	Ω. Frontal regions of the skin.
	O. Dorsal regions of the skin.
Inosculatory Mucous Membranes, etc.	H. Inosculatory mucous membranes.
	U. Cuteo-muscular sense of sight.
	Ω. Cuteo-muscular sense of touch.
	O. Cuteo-muscular sense of temperature.
Pachydermal Order.	H. *Cetacidæ and palæopachyderms: amphibious swine, whales, etc.*
	U. Pachydermidæ: trunkless swine, hippopotamus.
	Ω. Tapiridæ: snouted swine, tapirs.
	O. Proboscidæ: trunk swine, elephants.
Rodent Order.	H. Major tribes of rodents.
	U. House-mice (?)
	Ω. Field-mice, etc. (?)
	O. Harvest-mice, etc. (?)

Whales, dolphins, and herbivorous cetaceans, such as

the manatus and the halicore, may possibly rank in parallel with the transitory chorion of fœtal life and the cutaneous membranes of flying squirrels, bats, etc., while the extinct types of amphibious and terrestrial pachyderms may rank with the transitory forms of the proper skin. The genera of sirenia, delphinia, catadonta, and balena, form an anomalous series of amphibious swine. Hyrax, sus, rhinoceros, and hippopotamus, may be classed together as trunkless swine, or pachydermidæ proper. The tapirus forms a family type distinct from these, and the elephant a type still more distinct. Cetacidæ, pachydermidæ, tapiridæ, and proboscidæ, then, form distinct families or series, each containing one or more subordinate groups of genera and species.

Rodentine Order.—The rodents are confessedly most difficult to class in family series. The minute mucous ducts of glandulæ in the skin, connected with the sense of touch, and that of temperature, would seem to claim the smallest types of rodents as fit parallels; while the mucous membrane (conjunctiva) of the eye has evidently a distinct form and function, calling for a special parallel in the collective group. The fittest order of distinction in this case is too obscure to be suggested now. The general mucous membranes are easily distinguished as inosculators with the vascular, the alimentary, and the generative systems of the body; and, to some extent, the most prominent characteristics of the different tribes of the larger rodents are as manifest as those of carnivorous digitigrades, frugivorous and tree-inhabiting quadrumana, and omnivorous hibernating plantigrades. We have, therefore, a slight clue to the main natural distinctions of rodents in the different characteristics of hares, squirrels, and marmots, as leading types, around which we may group subordinate series or families.

The rodent order is much more complex than that of

any other alliance of mammalia; and so it should be, to correspond in parallel with the mucous membranes, inosculating with four distinct systems. The simplest way of shewing this inosculating correspondency of parallels will be to place the chief series of the quadrumanal, the digitigradal, and the plantigrade alliances in parallel with those sectional hyper-series of rodents which seem most nearly and naturally to correspond with them respectively in some of their main differential characteristics. The following parallels are merely approximative indications of a natural distribution; but they will be suggestive until further knowledge has been gained on these important questions:

DIGITIGRADES.	DASYPORODENTS.
1. *Felidæ.*	1. *Leporidæ.*
2. Hyænidæ.	2. Cavidæ.
3. *Viverridæ.*	3. *Lagostomydæ.*
4. *Profelidæ.*	4. *Chinchillidæ* (?)
5. Canidæ.	5. Dasyproctidæ.
6. Enhydridæ.	6. Castoridæ.
7. *Mustelidæ.*	7. *Muridæ.*

QUADRUMANA.	SQUIRREL RODENTS.
U. Cebidæ.	U. Pteromys.
O. Simiadæ.	O. Sciurus (common squirrels).
Ω. Ouistitidæ.	Ω. Sciuropterus.
H. Cheiropteridæ.	H. Anomalous types (?)
U. Indrisidæ.	U. Tamias, or ground-squirrels.
O. Lemuridæ.	O. Xerus.
Ω. Cheiromydæ.	Ω. Spermophilus.
H. Myslemuridæ.	H. Anomalous types (?)

PLANTIGRADES.	HIBERNATING RODENTS.
H. Extinct types.	H. Extinct types (?)
U. Ursidæ.	U. Arctomys, rhizomys, spalax, etc.
O. Edentidæ.	O. Hystrix, chætomys, ctenomys, etc.
Ω. Insectivoridæ.	Ω. Mole-rats, myoxus, arvicola, etc.
H. Monotremata.	H. Anomalous Australian types (?)
U. Urcomarsupidæ.	U. Ctenodactylus, cricetus, phleomys, etc.
O. Edento-marsupidæ.	O. Hapalotis, pseudomys, etc.
Ω. Insectivo-marsupidæ.	U. Heteromys, dipodomys, etc.

There are numerous species which may be naturally grouped with each of the leading types here named; but we need not dwell upon them now. With arctomys we may class rhizomys, spalax, aspalax, and aplodontia, in one series, with hystrix, chætomys, capromys, echymys, aulacandus, dactylomys, octodon, scizodon, abracoma, pœphagomys, bathiergus, ctenomys, etc. And so of other series in this section.

In the dasypo-rodent section, lepus and lagomys belong to one series; helamys, lagotis, and lagostomys, to another; kerodon, cavy, dolichotis, and capybara, to a third; castor fiber, ondatra, hydromys, and mystomys, to a fourth; paca, agouti, agouchy, to a fifth; common rats to a sixth, etc.

The different types are not as numerous in the series of the squirrel rodent section as in the different series of the other two main sections; but they are apparently more numerous in the hypno-rodent section than in any other.

The four sections of the rodent order are coextensive with four alliances of the mammalian class, and with all those of the class of birds. The latter correspond in parallel with the glandular connective tissues of the body, and these are mostly spread upon the surface of the skin and mucous membranes. Hence the correspondency between the glands and the cutaneous systems on the one hand, and the parallel order of distribution in birds and four of the alliances of the mammalian class on the other. The differential characteristics of the rodents are but faintly marked in parallel with the four alliances to which they correspond; but those of birds, which correspond in sections and series, are very markedly analogous. Analogies, however, are not safe guides in method, unless they are well supported by numerous other points of evidence.

Analogies and Parallels.—In forming natural sys-

tems and series we do not look for analogies, but evident distinctions and connexions. In the human body we first distinguish the connective tissues and fluids from the main tissues of the organs, and thus obtain four natural divisions. In the vertebrate realm we first observe the natural distinctions of type in fishes, reptiles, birds, and mammals, without regard to any notion of analogy or parallel between the four classes of tissues and fluids in the individual vertebrate organism, and the four classes of types in the collective vertebrate realm. This apparently accidental parallel of number and correspondency in the one primary and three secondary classes of each integral unit, is an after-thought, to be considered as an interesting point of coincidence.

In comparing the primary systems of the body with the manifest alliances of the mammalia, we also notice a coincidence of numbers and distinctions; but no particular analogy is evident, at first, in these parallel divisions. Nor does it matter, as a point of natural distinction in each case, whether analogies or correspondency of any kind be evident or not. Our business is not with analogy at first, but with natural delimitations only.

Are there seven systems in the body, or twelve natural divisions, and four natural series in each system? That is our first main question. Are there seven alliances, or twelve natural orders in the class mammalia, and four distinct families or series in each order? That is our second point of verification. Let us examine these two points.

The seven systems and their correlative inosculatory senses are too manifest to need discussion. Are there four natural series in each? In the vascular system the circulatory vessels form one distinct apparatus or series of organs, the respiratory another, and the urinatory a third. Is there a fourth transitory series in this system? or

should the umbilical and placental circulatory vessels be considered as a normal group of the general circulatory series? We believe the transitory placental blood-vessels should be classed as a distinct series.

The *nose* is evidently a distinct and special inosculatory organ in connexion with the respiratory apparatus; the *urethra* with the urinatory apparatus; the *lymphatic* and the lacteal vessels are also inosculatory with the circulatory series; and the *capillary vessels* are preeminently inosculatory between arteries and veins, in relation with all the organs of the body.

In the digestive system, the stomach, the small intestines, and the large bowels, are very distinct and definite organs or apparatuses; the mouth, pharynx, and œsophagus, inosculate with the stomach; the duodenum links the stomach with the small intestines; the anus and the rectum inosculate with the large bowel, and the chief digestive gland-ducts inosculate with the mouth and the duodenum. We can hardly define a special apparatus of digestion which is of transitory use and structure during fœtal life in man, but such an apparatus exists in the oviparous types of vertebrata; and in mammalia, the whole digestive system passes through a transitory series of metamorphic states.

The ovaries, the uterus, and the mammæ are three distinct organs or apparatuses of the generative system: and the oviducts, the vagina, and the nipples are inosculatory respectively with each of these. The marsupium is a fourth inosculatory organ in the generative system of one mammalian order, and the Wolffian bodies may be classed with other transitory forms in fœtal life, as a fourth or anomalous series of the generative system.

The osseous system contains a central or vertebral series of bones; a costal or medial series of ribs, etc.; an external or limb series; and a general hyperseries of arti-

cular cartilages in connection with the articulations of all these.

The nervous system is still more simple in its natural subdivisions, structurally or functionally considered. Mechanically it may be distinguished as central, medial, and peripheral; or, as relational, organic, and mixt (for the special senses), and in either case, the vesicular or ganglionic substance is articular.

The muscular system naturally follows that of the bones, in its main divisions, for the limbs, the costal series, and the vertebral. The osseo-muscular links or tendons, and the organs of vibratory sense are evidently inosculatory with this system; and the serial distinctions in all these are manifestly those which we have given in the tables.

The cutaneous system naturally follows the limbs, the costal, and the vertebral series, in its primary subdivisions; and the cuteo-muscular organs of radiatory sense inosculate with the system of the skin. The mucous membranes form a permanent inosculatory section of this system; and the chorion of fœtal life, a transitory surplus integument, continuous with the umbilical cord. We have, then, seven or twelve systems in the human body, and four series in each system, during fœtal life, which is the most complete in its array of special organs for the functions of mere physical existence.

What, then, of the number and the natural distinctions of form and structure in the collective organism of vertebrata? And, first, of the class mammalia. Are there seven alliances or twelve natural orders in this class, as we have seen? or could these alliances and orders be otherwise as well put into natural divisions? We believe not. But, are there four natural series or families in each order? and if not, why, and wherefore? That is an important question, and the first to be considered here.

We think the seven alliances cannot be impugned; nor can the twelve orders, although Cuvier deems the equine type a genus of the pachydermal order, and Huxley makes *homo* a family in the order of "primates." But what of the series or natural divisions of each order? Let us examine those.

In the quadrumanal alliance, all naturalists form two divisions: monkeys and lemurs. They also distinguish the old world monkeys from the new: and, in the latter, Cuvier separates the ouistitis from the cebidæ. We have, then, three natural families of monkeys, properly so called; and Linnæus as well as Cuvier placed the bats in close affinity with monkeys. There may be no analogy between the vascular system and the quadrumanal alliance, but there is a certain correspondency between the serial distinctions of the two. The monkeys proper form a chief series or family; the cebidæ form a second family; the marmosets a third. And, as the umbilical vessels form a transitory series of the vascular system, so the bats or flying monkeys form an anomalous series or family of the simial order of quadrumana. There may be no analogy between the two, but there is something like a curious correspondency of abnormality. Galeopithecus, roussettes, and bats, belong to this anomalous hyper-series of the quadrumanal type.

In the lemural order, Isidore Geoffroy St. Hilaire recognises three distinct families—lemur, cheiromys, and tarsier. Other naturalists have separated the indrisidæ as a distinct family from the ordinary lemurs. We deem these four divisions legitimate and natural; and here, again, we agree with men of eminence in this particular branch of natural science. There are, then, four natural series or families of monkeys, and four of lemurs, just as there are four series of vascular apparatuses, and four of an inosculatory order.

The digitigradal alliance also contains two orders; one of which has mostly retractile claws, and the other, unretractile. The first contains four series or families, *felidæ*, *viverridæ*, *mustellidæ*, and *profelidæ*, as given in our synopsis. The felines have the most retractile claws, except the cheetah, whose claws are hardly, if at all, retractile. The mustelidæ have mostly unretractile claws; and therefore this one characteristic not being universal in the order, is not, perhaps, a fit distinctive; but we cannot easily find one that is perfect. The word digitigrade is not completely applicable to all the families of this alliance, but is not as objectionable as less appropriate names might be. Seals are not properly digitigrade, but the transition from the otter to the kalan or sea otter is so manifest, and from this again to the seal, that we are constrained to place them in one family, the whole of which belong to this alliance. *Hyenidæ*, *canidæ*, and *enhydridæ* are, then, natural divisions of this order; and extinct forms of digitigrada, differing from all living forms, may well be classed in a separate group or series of the whole alliance. We need not seek for any parallel, at present, between the series of this division and those of the digestive system, beyond that of natural order, number, and distinction in each.

Of the plantigrade alliance we need say very little. It is easily distinguished into natural orders—the marsupial and the non-marsupial. *Ursidæ*, *edentidæ*, and *insectivoridæ* form natural divisions already recognised by all zoologists, though hitherto not grouped together in one order. They are, however, evidently plantigrade in form and structure, and have many other points of functional as well as structural affinity. Extinct types are also numerous in this order, and may be classed apart as a fourth group or hyper series.

The marsupial order is not so easily classed in separate

families, but some of them are evidently nearly parallel with bears in form and habits; others, with the insectivorous order of plantigrades; and very different from both of these are the most peculiar types of marsupiata, such as the kangaroos, the peramelidæ, and the chœropus ecaudatus. Our subdivision of marsupials into three distinct series may possibly require revision, but the fourth or anomalous series of monotremata is quite distinct and manifest. The kangaroo is plainly the central type of one marsupial family; the dasyurus of another; the small insectivorous opossums of a third; and the ornithorhynchus of a fourth. Phascolomys and phascolarctos are evidently ursiform marsupials, and most opossums, properly so called, may be grouped with these.

We need not here repeat the subdivisions of the equine order; nor those of the ruminant alliance, the only objection to which may be made against the separation of *camelidæ* from *auchenidæ*, and of *chevrotidæ* from *moschidæ;* and these distinctions, though slight, we deem legitimate.

The rodents are very naturally distinguished from pachyderms, as a separate order of the same alliance, but the natural subdivisions of these orders into families or sections are not so obvious. Elephants are quite distinct from tapirs, and these, again, from trunkless swine, such as the pig, the hippopotamus, and the rhinoceros. The hyrax is more or less distinct from all of these, although it has much in common with the tapirus and with the rhinoceros, in osteological structure. The cetacidæ, again, are evidently an anomalous family of pachyderms, claiming a place apart, either within the order or without. To us they do not seem much more anomalous as pisciform pachyderms, than the bats as flying monkeys; and as there are persistent transitory series of organs as well as transient forms in both the

vascular and cutaneous systems of the individual organism during fœtal life, so there may be anomalous series or families in the quadrumanal and the pachydermal orders, in some kind of unknown coincidence or correspondency, although we see no parallel, but one of abnormality. Umbilical and placental vessels are transitory and abnormal; the chorion or fœtal continuation of the skin is also transitory and peculiar; although other appendages of the cutaneous system, such as those of the collugo, and of flying or floating squirrels, are permanent in these peculiar types; still they are deemed anomalous prolongations of the general integument. Whales and dolphins may be classed as an ambiguous series of pachyderms, and bats as an ambiguous family of quadrumana, as the corresponding series are classed in the vascular and the cutaneous systems of the individual organism. Trunked swine, half-trunked swine, trunkless swine, and pisciform swine would thus form natural distinctions; but the pachydermidæ, properly so called, including the hyrax, the rhinoceros, the hippopotamus and the pigs, of different kinds, would seem to form a very much more diversified series of types in one family, than the tapiridæ and the proboscidæ respectively. It is a question that may call for more detailed investigation by and by; but for the present we may leave it as it is. The skin of the shoulder, the arm, the forearm and the hand; the hips, the thigh, the leg and the foot seem more diversified than the skin of the dorsal and frontal aspects of the head and the body alone. Hippopotamus, rhinoceros, sus, and hyrax do not appear to be more markedly distinct forms, than those of the hip, thigh, leg, and foot.

Ambiguous series are more or less complicate in all organic systems, and require minute investigation. In the cutaneous system of mammalian types, we have three kinds of anomalous articular elements to deal with:

namely, the permanent appendages of a cutaneous nature in the bats, the collugo, flying opossums, flying squirrels, etc.; the persistent chorion during fœtal life; and the transitory metamorphic states of the cutaneous system during uterine existence. In other systems of the body we have similar distinctions of anomalous or transitory forms more or less strongly marked; and in the complex organic unity of the whole class, in its alliances, orders, families, or series, we have corresponding types of anomalous forms and transitory extinct species. And these anomalies are all the more complex, as they form articular series or subsystems, in parallel with all the ordinary series of a special system, or all the systems of a special organism: just as the articulations of the osseous system run parallel with every bone, group, and series of the osseous system, in the human body.

The extinct types of vertebrata in every family and order during past ages of the world we place in organic parallel with the transitory metamorphic forms of the corresponding systems of the human body during fœtal life; anomalous living types of vertebrata we place in ambiguous or articular series, in parallel with life-long persistent anomalous organs in particular species, or with anomalous organs which only persist to the end of uterine existence: monotremata, in parallel with the life-long persistent marsupium, in one order; bats, with the anomalous series of persistent umbilical and placental vessels during fœtal life; whales, etc., with the anomalous hyper series of cutaneous appendages, such as the chorion and the "navel-string" during fœtal life; and not improbably the herbivorous sirenia may be more fitly arranged in parallel with the anomalous cutaneous appendages of flying squirrels and opossums, than with the transitory fœtal chorion. The extinct types of the normal series, such as anoplotherium, palæotherium, and mastodons may be

placed in parallel with the transitory forms of the whole skin during metamorphic evolution. This and other doubtful points of parallelism may long remain obscure without much inconvenience to science.

One law of order and degrees prevails, no doubt, in both the individual and the collective organism of vertebrata; the normal and the ambiguous types of organs, and series, run parallel with one another; but time and much attention will be necessary to form these parallels according to the strict analogies of nature. In the pachydermal order there are many extinct species of proboscidæ, tapiridæ, and other families of swine, and there are numerous metamorphoses or changes in the particular forms of the cutaneous system of the individual body, during fœtal life, before it attains to the perfect form of any given type. There are also many living anomalous species of pachyderms, and numerous instances of anomalous appendages to the cutaneous system, in certain species of the class mammalia. To form a perfect parallel between the normal and ambiguous series of the individual cutaneous system on the one hand, and the families of regular and anomalous pachydermal species on the other, is not, perhaps, a difficult task; but the idea being somewhat new, and therefore strange, we may just as well leave the question undecided for a time, as dwell upon a parallel which may seem naturally more or less farfetched at first, until the mind becomes familiar with the general theory of organic laws, in nature. Whales, dolphins, and sirenia are evidently anomalous living types of pisciform pachydermata, and more or less akin to these are certain extinct species: and all these forms are so decidedly imperfect, that we need not hesitate to place them in parallel with the imperfect skin or chorion of fœtal life. The hippopotamus and the hyrax are more or less anomalous pachyderms, and seem to claim a place in

parallel with some of the anomalous series of the individual cutaneous system, rather than among the regular series of the pachydermal order ; but this we may leave for a more elaborate investigation, when we deal with the general principles and laws of organic method. Meanwhile we may assume that the general divisions of the individual body and those of the mammalian class run parallel as systems and alliances ; and also in their subdivisions of normal and anomalous series, in both the individual and collective bodies. What analogy of functional relations or peculiarities there may be between the parallel series, in any, or in every instance, we need not now inquire ; but more elaborate analysis is not unlikely to present us with many features of resemblance that are now but dimly seen, or not at all.

REALMIC UNITY.

As in the human body we have one main class of organs and three secondary classes of connective tissues running parallel with all, or nearly all, the systems, so in the collective realm of vertebrata we have one main class of viviparous and three secondary classes of oviparous vertebrata, the latter running parallel with many of the natural orders and alliances of the mammalia. The parallel is, no doubt, perfect in both cases, but not easily described in either. Glandular tissues are easily collocated with the systems and the organs to which they belong, but adiposerous and areolofibrous tissues are not so easily differentiated in each region of the body. The class of birds is easily classed in parallel with mammals which have similar instincts and peculiar habits; but reptiles and fishes, though somewhat parallel in their peculiarities of instinct,

are not as easily arranged in manifest affinities. In this case natural distinctions are alone observed, without attempting to point out special collocations.

By collocation we mean association in organic union. In dissecting the body of an animal we see the natural connexions of one organ with another, one series with another, one system with another, and of the connective tissues with the whole. We look for the laws of order, number, and association, as well as the mere natural distinctions of one organ or one system from another; and in analysing a collective realm, we look not only for the natural distinctions of one species from another, one family or class from another, but also for the laws of order, number, and affinity, which bind the whole together in one complex union.

Hitherto the human body has been dissected with much skill, without looking for any general laws of order, number, and degree. The vertebrate realm has been carefully divided into classes, orders, families, and species, without regard to any higher laws of order, number, and affinity. This carving work of separation has been done in different ways by eminent zoologists, who lay the disjointed parts in different heaps, and claim respectively the merit of being one more skilful than another in adhering to the *natural method* of distinction and arrangement. But the simplest method of dissevering a body at the joints, is not the proper method of dissection; and the most careful dissection may be made without a due regard to the organic laws of order, as we have shewn in the complex organism of the human body. It would be very easy to carve the body and disjoint it otherwise than we have done, and also to dissever groups of animals from one another, and arrange them otherwise in classes and subclasses, orders and alliances; but not with due regard to the organic laws of order, number, and affinity, in one collective organism.

Analysis is one thing, synthesis another. We do not want to know the separate organs of the body only, but also the complex organic law of adaptation and cooperation in the living union of the parts before they have been disunited by analysis. We do not want to know the separate species, families, and orders, of a class or realm of any general type, but also the organic laws of order and affinity which bind them all together as a complex unity in epicosmic nature.

This is the end we have in view; and any method of arrangement which ignores this aim, has no pretension to synthetic order and natural method. It may be useful and convenient, analytically true, but not synthetically accurate. Let us study the connective or oviparous classes of vertebrata from this point of view, then, in parallel with the organic laws of order in the human body, but without attending to minute details.

CONNECTIVE CLASSES OF VERTEBRATA.—The general connective tissues in the individual organism, and the general connective classes in the realm of vertebrata, are of four kinds in both the individual and collective unities, and may be placed in parallels of order, number, and distinction, thus :

Connective Tissues.	H. *Transitory fœtal connective tissues.*
	U. Glandular tissues of the body.
	Ω. Adipo-serous tissues of the body.
	O. Areolo-fibrous tissues of the body.

Connective Oviparous Classes of Vertebrata.	H. *Extinct types of oviparous classes.*
	U. Birds.
	Ω. Reptiles.
	O. Fishes.

Connective tissues and oviparous classes, though running parallel in all degrees of modulation and diversity, are not so easily classed in systems and series as the most definite types of organic tissues in the body and alliances in the mammalian class. A general approximation to exact distinctions may, however, be obtained in both; and

that is all we need require. Birds, reptiles, and fishes, are very distinct types, and many of the antediluvian forms of fishes and reptiles are not less distinct from living types than these are from each other. Extinct types of birds are not, perhaps, so different from living types as the extinct saurians and sauroid fishes; but the epyornis, the dinornis, and some of the enormous birds which have left behind them fossil eggs, footprints in the sandstone rocks, and other traces of existence at a former period, shew that transitory forms of the oviparous classes have existed; and some of those which now exist may correspond to the fœtal rather than to the permanent connective tissues of the individual body. Be this as it may, we can notice such distinctions as we find, and form our parallels suggestively.

The glandular tissues are easily traced in the body, as they are mostly spread upon the skin and mucous membranes, terminating in small glandular depressions or in large agglomerations. The fibrous and areolar connective tissues are distributed in every part, but differ little in organic form and structure. Adipo-serous tissues, properly so called, are more or less analogous to glandular tissues, and secrete fat, marrow, or synovia, as the glands secrete bile or other excrementa. The amnion is properly a continuation of the cuticle of the skin, and therefore a kind of glandular membrane; while the primitive caducal membranes of fœtal life are more or less akin to the permanent areolar tissues of the body.

We may suppose that the same laws of order and number regulate the distributions and distinctions of connective tissues, as those which regulate the systems and series of the chief organs; but should we attempt to arrange oviparous types in correspondency with those of the mammalian class? Certain parallels are obvious, and these we may establish in their natural order without

being led astray by fanciful analogies. Organic parallels, however, are very faintly, if at all, indicated in the two classes, fishes and reptiles, although very obvious in birds; and therefore we may point them out at once, for the latter, while we merely indicate a few of the apparent features of resemblance in the former.

CLASS OF BIRDS.—If birds correspond in order, number, and distinction, with the glandular connective tissues of the individual organism, we can easily form a parallel between the families and orders of this class and the corresponding orders and series of the main class of vertebrata; and as the glandular tissues are only connected with four of the general systems of the body,—the vascular, digestive, generative, and cutaneous,—so we may expect to find birds corresponding in structure and instinct with only four alliances of the mammalia, namely quadrumana, digitigrada, plantigrada, and pachydermata. Parrots evidently correspond to monkeys, and eagles to lions; but what types correspond to the ursine order, and what to the porcine? As nearly as we can judge, the following orders and alliances of birds seem natural and most legitimate. The raptorial alliance we place in parallel with digitigrada, the scansorial alliance with quadrumana, the cursorial alliance with plantigrada, and the natatorial order with pachydermata. Thus:

RAPTORIAL ALLIANCE.

U. Falconidæ (felidæ).
U. Vulturidæ (hyenidæ).
O. Strigidæ (viverridæ).
H. *Fissirostridæ* (*profelidæ*).
O. Laridæ (canidæ).
Ω. Colymbidæ (enhydridæ).
Ω. Pelicanidæ (mustelidæ).
H. *Extinct raptorial types.*

SCANSORIAL ALLIANCE.

Scansorial Order.	H. *Cuculidæ*. U. Picidæ. O. Psittacidæ. Ω. Rhamphastidæ.
Conirostral Order.	H. *Paradiseïdæ*. U. Sturnidæ. O. Corvidæ. Ω. Conirostridæ.

The families of the raptorial alliance are here arranged in commingled orders, while those of the conirostral or

scansorial alliance are arranged in separate orders. This is merely a question of method which we need not dwell upon at present.

CURSORIAL ALLIANCE.

H. *Extinct cursorial types.*	H. *Apterygidæ.*
U. Grallidæ.	U. Rallidæ.
O. Cursoridæ.	O. Columbidæ.
Ω. Dentirostridæ.	Ω. Tenuirostridæ.

NATATORIAL ORDER.

H. *Phœnicopteridæ.*
U. Anatidæ.
Ω. Anseridæ.
O. Cygnidæ.

These four alliances include all families of birds, and differ very little, if at all, from the very simple and natural arrangement of the class in the zoological department of the British Museum. They are not there classed in four alliances, but in separate families of different orders. Our alliances are natural, however, and cannot be impugned on any principle of higher and more simple forms of organic generalisation.

Laridæ, colymbidæ, and pelicanidæ, belong undoubtedly to the raptorial alliance, although not hitherto so classed by working naturalists. Fissirostridæ are evidently nearer to raptorials than to any other type. The scansorial and the conirostral orders are manifestly natural, apart from each other, and not less easily combined in strict affinity as one alliance. The cursorial alliance may at first seem somewhat strange; but the natural affinities of form and structure, habits and instincts, between the orders and the families, will easily be seen on close examination. The natatorial order is already recognised as we have given it above.

Nor are the families less natural than are the orders and alliances: indeed, we introduce but very little change in the grouping of species in each family; and those which

may be deemed at first unusual, will easily be recognised as natural. In the raptorial alliance, the family *falconidæ* includes eagles, hawks, falcons, buzzards, harriers, the secretary bird, etc.; *vulturidæ*, gypaëtinæ, sarcoramphinæ, gypohieracinæ; *strigidæ*, all kinds of owls; *fissirostridæ*, caprimulgidæ (goat-suckers), todinæ (todies), trogoninæ (trogons), and alcedininæ (kingfishers); *laridæ*, all kinds of gulls and terns (larinæ, procellarinæ, diomedinæ, etc.); *colymbidæ* include all kinds of divers, auks, penguins, grebes, etc. (alcinæ, urinæ, colymbinæ, podicipinæ); *pelicanidæ* include pelicans, cormorants, gannets, and darters, in one family. The scansorial or conirostral alliance contains two very natural orders, and each of these four families. Cuculidæ, picidæ, psittacidæ, and rhamphastidæ, are very natural groups belonging to one order, the scansorial. Paradiseidæ, sturnidæ, corvidæ, and conirostridæ, are equally germane. Toucans, parrots, woodpeckers, and cuckoos, are already recognised as natural families of one order; and the families of the conirostral order are generally classed almost as we have grouped them here. *Paradiseïdæ* include paradiseinæ and colinæ; *sturnidæ* include buphaginæ, sturninæ, quixalinæ, icterinæ, agelaïnæ, graculinæ, and ptilonorhynchinæ; *corvidæ* include corvinæ, garrulinæ, calleatinæ, phonygaminæ; *conirostridæ* proper include bucerotinæ, musophaginæ, ophistocominæ, and fringillinæ or grossbeaks. In the cursorial alliance the families may seem at first remote from one another, but the groups in each are manifestly natural. *Grallidæ* include cranes, herons, snipes, and spoonbills; *cursoridæ* include struthioninæ, otidinæ, charadrianæ, cursorinæ, cracinæ, megapodinæ, phasianinæ, perdicinæ, tetraoninæ, pteroclinæ, odontophorinæ, turnicinæ, chionidinæ, thinocorinæ, tinaminæ. The distance may seem great between the ostrich and the plover in this one family; but not greater than that which is admitted in

the mammalian family of the edentidæ, which includes the sloths and the anteaters. The family of *rallidæ* includes rails, coots, etc. (rallinæ, gallinulinæ, parrinæ, palamedeinæ. *Columbidæ* include all kinds of pigeons, and perhaps the extinct dodo: thus didinæ, gourinæ, columbinæ, and treorinæ. If the dodo be denied a place in this family, it must be classed as a transitory type along with other extinct forms of more ancient genealogy. Most of the extinct types of birds, such as the gigantic æpyornis and dinornis, seem more or less akin to the ostrich or to the apteryx; but the remains of the dodo claim affinity with the pigeon tribe. Dentirostridæ and tenuirostridæ are recognised as natural families, but not as groups of this alliance. They cannot well be classed, however, with any of the others, and we believe they have a natural right to be arranged thus. The *dentirostridæ* include lanianæ, ampelinæ, meropinæ, muscicapinæ, and turdinæ. *Tenuirostridæ* include upupidæ, menurinæ, nectarinæ, meliphaginæ, and motachilinæ.

Along with *tenuirostridæ* are generally classed humming birds and creepers; along with *fissirostridæ*, swallows; but these we separate conditionally, for a special order of organic parallels, which may or may not prove legitimate, on more elaborate investigation.

Organic Parallels.—We recognise four sections of glandular distribution on the surface of the skin and mucous membranes, and three of these inosculate with the vascular, the digestive, and the generative systems; but, besides this general order of inosculation, we have another in the glandulæ of the cutaneous system, and the special senses of temperature, sight, hearing, etc. Now these inosculate in character and function with the three organic systems mainly, and to some extent, with those of the relational mechanism. The sebaceous glandulæ of the skin inosculate with the glands of the digestive sys-

tem; the perspiratory glandulæ, with those of the vascular system; the piliferous glandulæ, with those of the generative system. And as birds are placed in parallel with glands in general, so special families or groups in one case, correspond to special families or series in the other. Small birds would seem most naturally to correspond with minute glandulæ, and thence we place the smallest types connected with the raptorial alliance in parallel with the sebaceous glandulæ; the smallest species of creepers with the perspiratory glandulæ; and the smallest tenuirostrals with the piliferous glandulæ. From this point of view, *swallows* are detached from the fissirostral family, *creepers* and *humming birds* from the tenuirostral family, to form an order of secondary inosculators in parallel with the minute glandulæ of the external skin. The carunculæ and the lacrymal glands of the eyes, not to mention the special membranes which secrete the lenses and the humours of the eyeball, form another group of glandular tissues, having parallels, no doubt, in the connective class of birds; but it would carry us beyond the limits of these outlines, to discuss the question of organic parallels with such minuteness, as would be required to warrant special parallels for these. Mergansers might, perhaps, be separated from the family of ducks, to correspond with the glandular tissues of the eye, as distinct from those of the external skin, but this is not a question we need deal with now. Nor is it necessary, in a simple outline, to separate inosculators of this order, from the general alliances with which they naturally claim affinity. The simplest mention of this order of relationship is all we need attend to here. Elaborate investigations and minute details will find their place more properly elsewhere. Organic laws of order must exist in realmic groups and series, as well as in the systems and series of an individual organism; and general approxima-

tions when corrected will eventually lead us to more accurate organic parallels.

Class of Reptiles.—The adipous and serous tissues, properly so called, are quite distinct from the areolar tissues upon which and among which they are distributed, much the same as glandular tissues are distinct from the mucous membranes upon which they are sustained. Serous and synovial fluids have sometimes been supposed to be mere exhalations from the capillary vessels, but the microscope shows that epithelial cells exist on parts of the synovial membranes, and these are as distinct as adipous cells and their contents. There are, then, several kinds of internal secretive tissues in the body, more or less analogous to the external hyaline glandular excretive membranes. Exhalations of a simpler kind may lubricate the looser kinds of areolar connective tissues; but simple exhalations are quite distinct from *adipous and synovial secretions.*

The *oviparous* connective class of reptiles we place in parallel with the adiposerous connective tissues of the body, and in each we have four general subclasses very markedly distinct: thus, *serum* secretors, *synovia* secretors, *marrow* secretors, and *fat* secretors: *amphibians, ophidians, saurians, chelonians.*

Without looking for analogies of any kind, we may suppose the following parallels to be near enough for present purposes, and leave the question undecided. Serous connective tissues are universally distributed throughout the organism, but present much sameness of structure in every part; whence we may expect to find but slightly marked varieties of form and structure amongst the toads, frogs, and efts, which form the subclass AMPHIBIA or batrachia; commonly subdivided into five series or families: *ranidæ, salamandridæ, cæciliadæ, amphiumidæ,* and *proteidæ.*

Synovial sacs or bursæ are lined with synovia secreting tissues, which are also very simple in structure. They are mainly connected with the tendons of the muscular system and the articulations of the osseous system, and hence we expect to find the subclass OPHIDIA but little diversified in general and special types of form and structure. Such is the fact; for though the species are numerous, but few distinct families are recognised: there are but two sections of serpents; one being oviparous and innocuous, the other ovoviviparous and poisonous. The two families of *colubridæ* (snakes) and *boïdæ* (boas and pythons) belong to the first; vipers and marine serpents to the second. We need not dwell on the different genera of serpents, nor on the great differences of size between the very large and the very small species of venomous and innocuous types, as they are well described in popular works of natural history.

Fat secreting tissues are very general in distribution, though differing but little in peculiarities of structure. They are, however, more diversified than serum secreting tissues, and hence we may expect to find more numerous families, if not more species, of lizards than of serpents. The subclass SAURIA is subdivided into the following families: *crocodilidæ, chamælionidæ, gecholidæ, iguanidæ, varanidæ, teïdæ, lacertidæ, chalcidæ,* and *scincidæ.* One of the species of lacertidæ or true lizards is said to be ovoviviparous.

We need not describe crocodiles, alligators, monitors, scincs, geckos, chamælions, blind-worms, etc., the numerous species of which may be seen in the British Museum.

The marrow of bones is a special kind of adipous tissue limited to the osseous system, but subcutaneous fat and intermuscular deposits, may be classed as varieties belonging to the relational mechanism of the body; and

placed in parallel with the saurian subclass of reptiles. But besides the fat and marrow peculiar to the relational systems of the body, there are distinct kinds of fat peculiar to the organic systems; and these we place in parallel with the tortoises and turtles. These parallels, however, are made on very superficial grounds, and may, doubtless, be improved by more careful study.

The subclass chelonia are divided into four groups or sections: land tortoises; marsh tortoises (emydes); river tortoises; and marine tortoises (turtles). We need not here describe the genera and species of this subclass of reptiles, which is numerously represented in the British Museum; and we have no particular remarks to make on the natural distinctions of each group or series.

Class of Fishes.—The serous and synovial membranes, properly so called, are quite distinct from the secreting tissues lying on their surface, as the loose areolar tissues of the organism are distinct from the fat secreting cells of adipous tissue lodged in their interstices. Apart, then, from the secreting tissues commonly called adipous and serous, we have two kinds of fibrous connective tissue; the one being of a loose texture commonly called areolar, and the other of a denser texture forming sheaths and membranes. In this class of connective tissues we form two natural subclasses, *i. e.*, membranous and areolar; and in the class of fishes we have two primary divisions, the osseous and the cartilaginous. The first subclass is commonly divided into three sections: pectinobranchii, plectognathi, and lophobranchii. The second has no corresponding sections, but is divided at once into orders. It is, perhaps, unnecessary to dwell on the natural subdivisions of this class, until minute anatomy has separated different kinds of fibrous membranes and areolar tissues from each other in the body;

and a more elaborate investigation of the natural groups and series of fishes has been made; but the common arrangement is sufficiently accurate for our present purpose, and this gives us three orders of cartilaginous fishes; three orders in the first section of the osseous subclass, and one in each of the other two sections.

Sturgeons, sharks, and skates, are the chief types of the cartilaginous subclass; perches, gurnards, mackerel, the sword fish, mullets, wrasses, etc., are types of the first order of osseous fishes; carp, pike, salmon, herring, codfish, turbot, sole, etc., are types of the second order; eels of different species are classed as a third order; globe fishes and sun fishes form one section; the great pipe fish, the deep nosed pipe fish, etc., belong to the third section; and these are the main divisions of the osseous subclass. Some of the cartilaginous species are very large, and many of the bony fishes attain to a considerable size. Specimens of almost every known type may be seen in the British Museum.

One of the cartilaginous families are said to be viviparous, but the question has not been much investigated. The shark brings forth its young alive, and though we are not aware of any complete study of the life-history, and embryology of this particular family having been made by professed naturalists, we learn from Dr. Edward Brown-Sequard that he has frequently, in sailing from the Mauritius to France and back, captured very young specimens alive, with the umbilical cord still attached, and in every point resembling that of the young of a mammal; whence he concludes that the shark, though not a mammal, is certainly a placental and viviparous animal. If this view be warranted, the word *ovoviviparous* is not quite accurate, as here applied; and possibly the reptiles which are viviparous may not be merely internal hatchers of ova, but placentogestators.

If parallels be made between the connective tissues of the body and the special families of reptiles and fishes, for instance, as in the case of birds, then sturgeons may correspond to the areolofibrous tissues of the vascular system, sharks to those of the digestive, and skates to those of the generative system. This, however, is a question to be further investigated, before it can be settled.

Anomalous and Extinct Oviparous Vertebrata. —The connective tissues of the body are of three permanent classes and one transitory hyper-class, during fœtal evolution. We say one hyper-class, because these transitory forms of connective tissue are of various kinds, partly analogous to glandular and areolar tissues, and partly different, as in the case of preliminary and transitory envelopes, during the early periods of gestation. In the extinct types of the oviparous connective classes we may expect to find more reptiles than birds and fishes, and fossil or extinct saurians are probably more numerous than extinct birds and fishes.

Some types of extinct sauroïds we may place in parallel with the connective envelopes of the embryo, which are formed and disappear successively by absorption during the first periods of embryonic life, to be replaced by the chorion and amnion, which endure until the period of birth : some forms of extinct sauroid fishes may be classed not far from these, while others may be placed in parallel with the areolar connective tissues of the caducal placenta, umbilical cord, etc.

We need not enter into minute details of organic parallel, to separate one species of transitory absorbent tissue from another, in the caducal apparatus of the fœtus ; nor one species of extinct saurian from another : but merely call attention to the known fossil remains of such types as those of pterodactylus, ichthyosaurus, geosaurus, mosa-

saurus, plesiosaurus, iguanodon, etc.; restorations of which may be seen amongst the antediluvian animals represented in the grounds of the Crystal Palace at Sydenham. All we need say here is, that anomalous and extinct types of oviparous vertebrata claim a place in organic parallel with the transitory connective tissues of the fœtus: extinct types of birds being placed in parallel with the glandular amniotic tissues; extinct sauroïds, with preplacental and absorbent envelopes; extinct fishes with the areolar tissues of the transient placental apparatus.

The whole collective realm of vertebrata, as a complex bisexual organic unit, may be placed in parallel with the individual human body, male and female, as a complex bisexual organic unit, and the following synoptic tables will show this parallel in all the natural divisions of each complex bisexual organism.

INDIVIDUAL VERTEBRATE ORGANISM.

Z. Supernal Forces and Conditions.	H. *Uterine supplies, etc.* U. Climatic conditions. Ω. Food resources. O. Physiorganic forces, etc.
Y. Ingesta, etc.	H. *Impregnata.* U. Investa and infesta. Ω. Recent ingesta. O. Blood and lymph.
X. Secretions and Exuviæ.	H. *Parturitional out-births.* U. Glandular excretions. Ω. Fat and synovia, etc. O. Sloughs and necrological exuviæ.
W. Connective Tissues.	H. *Fœtal amnion.* U. Glandular tissues. Ω. Adiposerous tissues. O. Areolo-fibrous tissues.
VII. Vascular System.	H. *Placental vessels.* U. Respiratory vessels. O. Circulatory vessels. Ω. Urinatory vessels.
·7. Vascular Senses.	H. *Capillary vessels.* U. Nose. O. Lymphatic vessels. Ω. Urethra.

VI.	DIGESTIVE System.	H.	*Transient forms.*
		U.	Stomach.
		O.	Small intestines.
		Ω.	Large bowels.
·6.	Digestive Senses.	H.	*Digestive gland-ducts.*
		U.	Mouth and œsophagus.
		O.	Duodenum.
		Ω.	Anus and rectum.
V.	GENERATIVE System.	H.	*Transient Wolffian bodies.*
		U.	Ovaries.
		O.	Uterus.
		Ω.	Mammæ.
·5.	Generative Senses.	H.	*Marsupium in kangaroos.*
		U.	Oviducts.
		O.	Vagina.
		Ω.	Nipples.

IV.	NERVOUS System.	H.	*Ganglionic nerves.*
		U.	Relational nerves.
		Ω.	Mixed nerves.
		O.	Organic nerves.
III.	OSSEOUS System.	H.	*Articular cartilage.*
		U.	Limbs, series of bones.
		Ω.	Costofacial series.
		O.	Craniovertebral series.
·2.	Osseo-tendinous Senses.	H.	*Fascia.*
		U.	Ears.
		Ω.	Glottis.
		·O.	Tendons.
II.	MUSCULAR System.	H.	*Cutimotor muscles.*
		U.	Limb-motor muscles.
		Ω.	Costo-motor series.
		O.	Vertebro-motor series.
·1.	Cuteo-muscular and Muco-dermic Senses.	H.	*Mucoderm.*
		U.	Eyes.
		Ω.	Touch; palms.
		O.	Temperature.
I.	CUTANEOUS System.	H.	*Transient chorion.*
		U.	Skin of limbs.
		Ω.	Skin of face and trunk.
		O.	Cranio-dorsal skin.

VERTEBRATE COLLECTIVE UNITY.

Z.	Comparative Supernal Forces and Conditions.	H.	*Comparative uterine supplies.*
		U.	Climatic conditions, comparative.
		Ω.	Food-resources, comparativo.
		O.	Physiorganic forces and instincts.
Y.	Comparative Infesta and Ingesta.	H.	*Impregnata.*
		U.	Investa and infesta.
		Ω.	Ingesta.
		O.	Blood.

X.	Comparative Secretions and Remains.	H.	*Remains of extinct types.*
		U.	Glandular excretions, coprolites, etc.
		∩.	Adiposcerous lubrications.
		O.	Moults and reliquiæ.
W.	Connective Oviparous Classes.	H.	*Extinct types of ovipara.*
		U.	Birds.
		∩.	Reptiles.
		O.	Fishes.
VII.	SIMIAL Order.	H.	*Cheiroptera.*
		U.	Cebidæ.
		O.	Simiadæ.
		∩.	Hapalidæ, or marmosets.
·7.	Lemural Order.	H.	*Microlemuridæ.*
		U.	Lemuridæ.
		O.	Indrisidæ.
		∩.	Cheiromydæ.
VI.	CANINE Order.	H.	*Extinct digitigrada.*
		U.	Hyenidæ.
		O.	Canidæ.
		∩.	Phocidæ.
·6.	Feline Order.	H.	*Profelidæ.*
		U.	Felidæ.
		O.	Viverridæ.
		∩.	Mustelidæ.
V.	URSINE Order.	H.	*Extinct plantigrada.*
		U.	Ursidæ.
		O.	Edentidæ.
		∩.	Insectivoridæ.
·5.	Marsupial Order.	H.	*Monotrematidæ.*
		U.	Ursomarsupidæ.
		O.	Macromarsupidæ.
		∩.	Micromarsupidæ.
IV.	ANTHROPINE Order.	H.	*Mediumistic races.*
		U.	Temperate clime races.
		∩.	Subtropical races.
		O.	Tropical races.
III.	EQUINE Order.	H.	*Hybrids.*
		U.	Horses.
		∩.	Zebras.
		O.	Asses.
·2.	Hornless Order of Ruminants.	H.	*Camelidæ.*
		U.	Moschidæ.
		∩.	Chevrotidæ.
		O.	Anchenidæ.
II.	HORNED ORDER of Ruminants.	H.	*Giraffidæ.*
		U.	Cervidæ.
		∩.	Antilocapridæ.
		O.	Bovidæ.
·1.	Rodent Order.	H.	*Macromurida.*
		U.	House-mice (?)
		∩.	Field-mice (?)
		O.	Harvest-mice (?)

I.	PACHYDERMAL Order.	II. *Cetacidæ and sirenia.*
		U. Pachydermidæ.
		Ω. Tapiridæ.
		O. Proboscidæ.

CONCLUSION.—Professional naturalists very properly follow the inductive method of observation and description in their anatomical and physiological investigations, and in these they necessarily agree at last; but, notwithstanding this agreement, they all differ from each other, more or less, in philosophical views of order and arrangement. As working naturalists they agree; as philosophical naturalists they disagree, or differ amicably, as the case may be; but still they differ, and they differ widely, from each other. They may possibly not admit our views of method and arrangement. We do not admit theirs.

In establishing four classes of vertebrata, and subdividing them respectively into orders, families, and species, their task is done. Not so with ours. We wish to know something more of organic unity than this in every realm. There are differential classes, differential secretions, differential ingesta and infesta, differential dynamic forces and conditions in the vertebrate organic realm. We need not enter deeply into all these questions, but they claim attention as connective elements of life and organisation.

The main thing in the study of organic unity is not to lose sight of general distinctions while engaged in the analysis of small details; and when small natural groups have been established in the vertebrate realm, the main divisions must be sought for before intermediate degrees of aggregation are attempted.

In the human body all the organs, groups, series, and systems, are so markedly distinct that they are easily recognised and classed in order; but the different types of the collective realm are not so easily classed in their natural relations of species, groups, series, and orders. The anomalous families are more especially embarrassing,

as their affinities have not the same advantage of local and functional association as anomalous groups of organs in the human body. It is to primary distinctions, therefore, that attention must be given mainly in the study of collective unity, that multiplex details may not confuse the mind before broad outlines are sufficiently established.

It is better also not to fix the mind on superficial analogies and correspondencies before we have obtained clear parallels of order, number, and affinity. These being once established, lead naturally to the nearest aspects of analogy and similarity. That there are two sexes in the human race and in every species of vertebrata, is quite plain; that there are three classes of connective tissues and one class of main tissues in the individual organism, is equally clear; and that three classes of oviparous vertebrata are contrasted with one class of mammalia in the collective realm, is also manifest. To this extent the parallel between the natural divisions of the individual organism, and those of the collective realm, is plain and simple.

That there are seven systems and five senses in the body of a vertebrate animal, irrespective of connective tissues, is certain; and that there are seven alliances, or twelve natural orders of mammalia, irrespective of the three oviparous classes of vertebrata, is equally manifest in the collective unity of the whole realm. Thus far, then, one law of order and association rules in the relation of parts in both the individual and collective unities of vertebrate organic form and structure. And again, there are three normal series and one articular anomalous hyperseries in each of the seven systems and five inosculatory senses or sub-systems of the human body. And we think it cannot be disputed that in each of the twelve orders of mammalia there are three natural families and one anomalous group (series or hyper-series), neither more nor

less; and that no other distribution of these groups and series could be deemed more natural from any point of view whatever. A few points of definite grouping are still unsettled; but they are not very complicated.

Nor can it be said that any preconceived ideas of number and arrangement have formed an arbitrary bed for groups and series to be stretched upon, for no one order or alliance claims the same definite number of genera and species as another: diversity is everywhere perceived in natural divisions and alliances. The general conditions of life are the same for individuals, species, families, orders, and classes, which belong to the same realm; and therefore we may conclude that realmic complex unity is manifestly subject to the same organic law as individual complex unity.

That all the realms cooperate in mutual relations is manifest; but what are the internal laws of order in each realm respectively? and what connexions are there between all these realms? The number of distinct realms, as we have seen, is twelve, and each of these forms a complex unit analogous to that of the human body. We may therefore expect to find the same laws of order in each of the twelve, much as we have found them in the realm of vertebrata.

Before we analyse the other realms we ought to investigate the comparative physiology of vertebrata in parallel with the physiology of the human body; but this would require a volume to itself, and therefore we defer it, and restrict our inquiry mainly to the laws of systematic order and affinity; not only to the laws of order, but to a very brief outline of these laws in the primary and secondary subdivisions of each realm.

It is not, strictly speaking, the anatomy and physiology of the realms we have to deal with; but the laws of order, number, weight, and measure, which underlie the

forces and phenomena of comparative anatomy and physiology. A few short pages will suffice, then, for a brief outline of these factors in each realm.

OUTLINES OF ARTICULATE ORGANIC UNITY.

SYNTHETIC ARRANGEMENT.—After the vertebrata, the articulata is, perhaps, the most important of organic realms. Mollusca holds a higher rank, but on a lower gradus of the general plan ; the one being a member of the diatonic, the other of the chromatic scale of taxionomic gradation. We easily recognise four classes of articulata. Arachnida and myriapoda have sometimes been placed with insects, and oftener as distinct classes. We believe arachnids and crustaceans to be subdivisions of one main class ; insecta, myriapoda, and annelida, form distinct secondary classes ; and this appears to be warranted by numerous affinities of structure. Naturalists have stated that " spiders must not be confounded with insects, from which they differ in having lungs, in possessing eyes very much like those of vertebrate animals, a different cerebral organisation, and higher intelligence."

In the highest individual organism, we find vascular, digestive, and generative systems; nervous, muscular, and cutaneous systems ; and although no osseous system is well developed in any type, there are fibrous rings in the annelida, which serve as levers for the muscular fibres to act upon. In the crustacea a sort of external skeleton serves as a basis of attachment for the muscular system, but this is an incrustation more or less analogous to the external shell of a tortoise, or that of an armadillo, in the vertebrate organism. There is, then, in some types a

rudimental system of resistive factors in the articulata, as well as in mollusca. Organs of sight and hearing exist in the crustacea, and some degree of smell and taste may be attributed to bees and other insects, which recognise the flowers that afford them honey. Some moths are known to travel miles to find the female in concealed places, such as private rooms or cases; and many facts well known in the life history of the articulata prove they are endowed, in some degree, with the five senses.

The seven systems with the five senses are not as highly developed in the articulate organism as in the vertebrate, but they are equally curious and interesting. The eyes of insects are more complex, in some respects, than those of higher types; and the simpler generative system is more diversified in plants and lower animals, than in the vertebrata, but these diversities do not interfere with the general principles of organic parallels. In vertebrate organisms, the reproductive system varies in different classes and species. Birds hatch their eggs, and give no suck to their young; and even in the mammalian class, some are placental and some implacental. There is not a complete generative system, then, in any one individual organism. Even the highest types have no marsupium, as an auxiliary apparatus, which is peculiar to the order of marsupiata. The task of reproduction is distributed to several organisms, in some cases, and sometimes to a single hermaphrodite individual. In the female of the highest mammal type, there is an apparatus for ovagenesis, another for gestation, and a third for lactation: ovaries, uterus, and mammæ. The first produces from the blood a homogeneous substance for the germ; the second, a different kind of substance from the blood; the third produces milk, which is a further differentiation of the blood; and all for the same purpose, to furnish a plastic substratum for the physiorganic forces to trans-

form into living tissues and organs. In the lower classes of vertebrata, birds, reptiles, and fishes, we do not find the same complexity of structure in the generative system of individuals; and in lower realms of animated nature, we find still less complexity of structure, with more diversity, in the distribution of the reproductive functions. Besides the male and female sexes in distinct organisms, there are neutral, bisexual, and hermaphrodite individuals, reproducing the species, in both animals and plants. There is fissiparitive generation, metagenitive reproduction, and bisexual reproduction. It is not the special organs of generation, then, in a single organism of the articulate type, we have to look for, but the leading forms of genetic apparatus in the class, these being sexual or neutral.

In a plant the flowers are sexual which produce seed; while the buds which produce branches or individual plants, are not sexual, but neutral; and the bulbils which also reproduce the plant, are neutral. In certain insects commonly called plant-lice (aphis) some individuals which are neither male nor female, reproduce the species by what is called genetic alternation, or "metagenesis," while others, being sexual, generate the species in the usual way. We have ovagenitive and metagenitive apparatuses in the generative systems of the class; and these are merely differentiations of the same organs for like functions. In higher animals, the three distinct kinds of genetic apparatus are but successive means of adaptation to one sole purpose. It is, therefore, of no fundamental importance whether there be only one main apparatus, or three main series of organs, in the generative system of an individual organism.

There is a complete scale of systems in the highest types of articulata, and we may expect to find a complete scale of natural orders and alliances in the main class, including arachnida and crustacea.

Milne-Edwards establishes five divisions of crustacea and three types of arachnida: namely, *podophthalma, edriophthalma, branchiopoda, entomostraca*, and *xyphosura* ; *pulmonaria, pulmotrachearia* (les segestries), and *trachearia*. These are again subdivided into orders and sections, genera, and species ; and although we admit most of his natural subdivisions, we shall have to alter some of their relative degrees of rank, in forming an organic parallel between the individual and collective units of articulata. The difference, however, is very little ; being more a question of names and parallels, than one of natural delimitation.

Cuvier himself observes that "Doctor Leach arranged the myriapoda as a distinct class ;" and that "the trachealian arachnida might also be arranged as a distinct class, according to certain peculiarities of structure, anatomically considered ; but they have so many affinities with the pulmonary arachnids that he did not think they should be separated from them in a classical arrangement."

From this, it is evident that Cuvier was puzzled with the subdivisions of arachnida ; not in determining structural differences, but in distributing alliances or graduated subdivisions. Organic parallels make this an easy matter, without doing violence to any of the natural distinctions pointed out by Cuvier and other eminent zoologists. True spiders differ from true scorpions in a marked degree, and trachealian pseudoscorpions and pseudospiders differ again from both, and from each other. We may easily distinguish three alliances in this subclass ; and a careful view will recognise two orders in each alliance. Pulmonic spiders form one alliance ; pulmonic scorpions another ; and the *holètres* or trachealian arachnids of Cuvier form a third.

And here we may observe that the most eminent zoolo-

gists differ widely from each other in their primary divisions, although they may be equally conversant with structural and physiological distinctions in every department of natural history. This divergency can only be caused by the want of a general principle of taxionomic method. In the first divisions of the articulata, Cuvier (or Latreille in his name) makes four classes, *i.e.*, *crustacea*, *arachnida*, *annelida*, and *insecta;* Milne-Edwards five, *i.e.*, *insecta*, *myriapoda*, *arachnida*, *crustacea*, and *annelida*. The order of precedence is reversed in these two systems, and their secondary subdivisions are almost as incompatible as the primary. Cuvier makes two subclasses of crustacea, *i.e.*, *malacostraces* and *entomostraces*, the first of which he subdivides into *decapodes*, *stomapodes*, *amphipodes*, *læmodipodes*, and *isopodes ;* the second into *branchiopodes* and *pœcilipodes*. Milne-Edwards makes no primary distinction between malacostraca and entomostraca, but subdivides the whole class at once into five principal groups, which he calls *podophthalma*, *edriophthalma*, *branchiopoda*, *entomostraca*, and *xyphosura*. By this arrangement he places three of Cuvier's divisions into one group of edriophthalma, and separates xyphosura from entomostraca. We need not think, then, that a vast acquaintance with details had given either of these great zoologists a knowledge of organic principles as we have now to understand them.

The arachnida form three natural alliances, or six orders; the crustacea four alliances, or six orders; agreeing partly with those of Cuvier and Milne-Edwards, though not with either literally. Our arrangement may not be final, but it is sufficient for the present.

In Cuvier's works, Latreille has placed the myriapoda with insects; but they have been placed in a distinct class by Milne-Edwards. This arrangement gives us three connective classes of articulata and one main class, as in

the realm of vertebrata. Milne-Edwards separates vermicula from annelids, and makes four classes of the latter; but this leads to confusion of ranks in primary distinctions. He makes nine classes of articulata in lieu of four, and five of the nine are merely worms. Vermes and vermicula are natural divisions of one class, and both are properly subdivided into minor sections.

For the sake of simplicity the main class of articulata may be called *articulata*, including the two sub-classes of *crustacea* and *arachnida;* the connective classes of annulosa being *insecta, myriapoda,* and *annulata.*

In a general synopsis of this realm the natural orders and alliances will stand in parallel with the systems of the individual organism, just as we have found them in the vertebrate realm.

CLASSIFICATION OF ARTICULATA.

Annulosa.	Z.	Supernal Forces.	H. *Embryonic supplies of food, etc.* U. Climatic conditions of life. Ω. Food resources in realms. O. Physiorganic forces and instincts.
	Y.	Differential Ingesta, etc.	H. *Impregnata.* U. Investa of articulata. Ω. Recent ingesta of articulata. O. Blood of articulata, etc.
	X.	Differential Exuviæ, etc.	H. *Larvæ and pupæ of all classes.* U. Excretions of all classes. Ω. Secretions of all classes. O. Necrological exuviæ of all classes.
	W.	Annulosa (Connective Classes).	H. *Extinct types of annulosa.* U. Class insecta. Ω. Class myriapoda. O. Class annelata.
Arachnida.	VII.	ARANEA Sedentaria.	H. *Unknown (?)* U. Rectigradæ. O. Mygalidæ. Ω. Laterigradæ.
	·7.	Aranea Vagabundia.	H. *Unknown types (?)* U. Saltigradæ. O. Unknown types (?) Ω. Citigradæ.
	VI.	SCORPIONA.	H. *Unknown types (?)* U. Scorpionidæ. O. Phrynidæ. Ω. Cheliferidæ.

	·6.	Solpugia.	H.	*Unknown types (?)*	
			U.	Solpugidæ.	
			O.	Unknown types (?)	
			Ω.	Galeodidæ.	
	V.	HOLETRA.	H.		
			U.	Phalangidæ.	
			O.	Macrochelidæ.	
			Ω.		
	·5.	Acarida.	H.		
			U.	Acaridæ.	
			O.	Pycnogonidæ.	
			Ω.		
Crustacea.	IV.	BRACHYURA.	H.	*Natans.*	
			U.	Arcuata, quadrilatera.	
			Ω.	Orbiculata.	
			O.	Trigonia, cryptopoda, notopoda.	
	III.	ENTOMOSTRACA.	H.	*Cirrhipoda.*	
			U.	Brachyopoda.	
			Ω.	Syphonostoma.	Pœcilipoda.
			O.	Xyphosura.	
	·2.	Multipedia.	H.	*Isopoda.*	
			U.	Læmodipoda.	
			Ω.	Amphipoda.	
			O.	Stomapoda.	
	II.	LOCUSTINA.	H.	*Anomaluridæ.*	
			U.	Ibacidæ.	
			Ω.	Scyllaridæ.	
			O.	Palinuridæ.	
	·1.	Caridina.	H.	*Cragnonidæ.*	
			U.	Alphæidæ (?)	
			Ω.	Rhynchocirectus (?)	
			O.	Unknown types (?)	
	I.	ASTACINA.	H.	*Galathea* (?)	
			U.	Thallasinidæ.	
			Ω.	Callianassidæ.	
			O.	Astacidæ.	

REALMIC UNITY.—This table gives the nearest approximation to a complete parallel, that we can make at present. The discovery of species yet unknown, may possibly afford answers to the queries here inserted. It may be, also, that unknown species might claim other places than those implied in our synopsis; but these are questions which cannot be decided beforehand. It may be that the groups and families already recognised are not well named, and that a more careful method of divarication would establish more numerous divisions with better

names and definitions. Our own special knowledge of this realm is not sufficient to determine all these points; and we are too busy with other branches of special science to devote more time to this.

The classes and alliances are definite enough, in this synopsis, and the secondary subdivisions may be as incomplete in number and development in the main class of articulata, as the systems and series of organs are rudimentary in the highest individual type of an articulate organism. Meanwhile we give the symbols of a complete scale of series or families in each alliance, and future investigations will have to decide the question of complete or incomplete development in realmic collective unity.

In *The Rambles of a Naturalist,* by A. De Quatrefages, the articulata are first arranged in two divisions, as "*true articulata*" and "*vermes.*" These are subdivided into twelve so called classes: "insecta, myriapoda, arachnida, crustacea, and cirrhipoda, belong to the first division; annelida, rotifera, gephyura, lumbricini, hirudinei, turbellaria, and helminthes," to the second.

We need not dwell on this arrangement, as it is not in minor divisions, but in general grouping that we differ. He also differs from Cuvier in forming but two main distinctions in the "animal kingdom" in lieu of four. Three of Cuvier's divisions are thus classed together as *invertebrata,* contrasted with the *vertebrata.*

In such an arrangement the most obvious differences of structure are seized upon as points of separation, without regard to number, order, or degree: and therefore it is purely conventional. Organic parallels are evidently much more natural and simple.

Analytical divarication and synthetical arrangement are very distinct things, in the systematic classification of a realm; and the most eminent zoologists have hitherto had no other end in view, than that of analytical distinc-

tion. We cannot, therefore, expect to find a natural arrangement, where no such views were thought of, by the author of a special system. All naturalists agree in the distinction of races, species, tribes, and families; and we agree with them to this extent; but higher groups and orders, classes and subclasses, sections and alliances, require synthetical as well as analytical ideas of method, to determine the true laws of natural arrangement.

The same dissidence of method amongst working naturalists, is manifest in every department of zoology and botany; not only with regard to names and definitions, but also with regard to analytical divisions. We cannot agree with any one of them, without, in some respects, differing from others. And still their views are mostly based on some legitimate distinction, found in nature. Their disagreements are not so much on natural distinctions, as on methodical arrangements. We only differ from them, therefore, as they differ from each other; and we place our one deductive principle of method, in contrast with their numerous conflicting illustrations of inductive method. They look for natural diversities alone or mainly; we look for synthetic unity as well.

Class Insecta.—At the head of the connective classes of articulata we place insects, as birds are at the head of the oviparous vertebrata. In both realms, these classes are placed in parallel with the glandular connective tissues, and these are conjoined with four alliances of the highest class. We have, therefore, only four alliances or seven orders of birds, and the same organic law applies to the alliances and orders of insecta.

Linnæus forms seven orders of insects; Mr. Waterhouse, eight; and Milne-Edwards, ten. These discrepancies are more apparent than real, and may, to some extent, be reconciled in our arrangement, which includes four alliances or seven orders, corresponding with the

natural divisions of the vascular, digestive, generative, and cutaneous glandular tissues.

The four alliancés of insects may be named according to the leading types of each ; *i.e., lepidopteral, hymenopteral, orthopteral,* and *coleopteral,* although we deem the wings of secondary importance in separating groups from each other; but as these have been generally deemed convenient for naming chief distinctions, we adopt them, as subordinate to other structural and physiological characteristics. The lepidopteral alliance contains two orders, *i.e.,* butterflies and moths : the hymenopteral alliance contains also two orders, the one being that of hymenoptera properly so called; the other, including in one neuropteral order, three sections commonly called *neuroptera, diptera,* and *rhipiptera.* The orthopteral alliance includes in one order the two groups of *orthoptera* and *homoptera* properly so called, and separated from hemiptera ; and, in a second order, the two apterous groups of "parasites" and "thysanoura" as established by Milne-Edwards. The coleopteral alliance forms a single order, as already well defined by eminent zoologists.

It would require considerable space to enter into a minute investigation of our reasons for adopting these organic parallels, but the natural affinities of all the groups appear self-evident ; and what we have already said in other chapters, on the question of organic method, will suffice. We shall merely give a general synopsis, then, of the class insecta, and proceed at once to the other two connective classes of articulata.

SYNOPSIS OF CLASS INSECTA.

VII.	MOTHS. (*Heterocerca.*)	H. *Plissipennidæ (pterophorites).*
		U. Crepuscularidæ (sphingidæ).
		O. Nocturnalidæ (bombicidæ, noctuidæ, etc.)
		Ω. Heteronocturnalidæ (phalænidæ, etc.)
·7.	Butterflies. (*Rhophalocerca.*)	H. *Anomalous lepidoptera (lycænidæ).*
		U. Papilionidæ (papilionidæ heliconidæ.)
		O. Vanessidæ (nymphalidæ).
		Ω. Danaïdæ (erycinidæ).

VI.	HYMENOPTERA.	H. *Extinct types, etc.* U. Pupivoridæ. O. Aculeatidæ. Ω. Securifera.
·6.	Neuroptera.	H. (*Diptera pupiaires*) *amaloptera.* U. Diptera. O. Neuroptera. Ω. Rhipiptera.
V.	ORTHOPTERA.	H. U. Orthoptera. O. Homoptera. Ω.
·5.	Hemiptera.	H. —— U. Hemiptera. O. Aptera. Ω.
I.	COLEOPTERA.	H. *Trimera.* U. Tetramera. O. Heteromera. Ω. Pentamera.

We have subdivided the nocturnal lepidoptera into three sections or families; the plissipennidæ, being a section already recognised; and what we call heteronocturnalidæ include other sections which are more or less irregular in structure. Latreille observes that "Several of the nocturnal moths have no proboscis, and some of the females have no wings... the whole family is difficult to arrange in natural order, and our methods are still, in this respect, but very imperfect and tentative."

The *hemiptera*, as here defined, include the "geocorises" and the "hydrocorises" of Milne-Edwards (punaises; nepes, nostonectes). The *aptera* include his "succurs" (puce), "parasites" (pou), "podure, thysonoure."

For more details and special information, we refer the reader to Westwood's works on insects, and other standard writers on this branch of natural science. Names and definitions are numerous and various in this department, and further studies will be necessary to settle all such questions. Meanwhile, the main divisions are correct as given above, and secondary groups are easily arranged.

The insects are a very numerous class, which have been well observed; and little is required to simplify the

names and definitions of all natural divisions. The myriapoda are much less numerous and various, and, therefore, easily dealt with.

CLASS MYRIAPODA.—This class is naturally subdivided into two subclasses; *i. e.*, *chilognatha* and *chilopoda*, or millipedes and centipedes. In each of these there are several tribes or genera, which need only to be mentioned in a general synopsis:—

MILLIPEDES.	1. Glomeris. 2. Iulus. 3. Polydesmus. 4. Polyxena.	CENTIPEDES.	1. Geophilus. 2. Lithobia. 3. Scutigera.

The species are more or less numerous in each of these families.

CLASS ANNELATA.—Milne-Edwards makes four classes of the lowest types of annulosa; *i.e.*, annelids, turbellaria, rotifers, and helminths, but these are only entitled to rank as alliances. Two subclasses may be recognised, one of which is much above the other in development, and hence we apply the name of *annelids* to the first, and that of annuloïda or *vermicula* to the second. Cuvier subdivides the annelids properly so called, into three main groups, and places the vermicula in the realm of radiata. This mistake has been rectified by Milne-Edwards.

The annelids form three alliances, named by Cuvier *abranchiata*, *dorsibranchiata*, and *tubicolæ*. The first have no branchial tufts; the second have branchial appendages on the back; and the third are tube makers. The earth worm, the naïs, the leech, and the hair-worm belong to the abranchiata; the lugworm (arenicola piscatorum) and the sea-mouse (aphrodita aculeata) belong to the dorsibranchiata, which are all marine. The tubicolæ inhabit tubes of their own formation; and these are sometimes composed of calcareous matter secreted by the skin of the animal, and sometimes of small particles of sand or shells, agglutinated together by a gelatinous substance secreted by the worm.

M. A. De Quatrefages forms seven classes of "vermes;" *i. e.*, annelida, rotifera, gephyria, lumbricini, hirudinei, turbellaria, and helminthes. The first three of these he classes together as *monœcious vermes*, in which all the individuals are bisexual; the others being unisexual, are classed together as *diœcious vermes*. This method is no better in zoology than it would be in botany, where it is obviously inadmissible. Annelida, lumbricini, hirudenei, belong to one subclass; gephyria, turbellaria, rotifera, and helminthia to an inferior subclass. The gephyria (sipunculus and echiurus) were classed with the synapta, as tubiculous types of radiata, by Cuvier, but modern science claims them as true vermes.

The structural and physiological characteristics of all known *annelids* have been described in works of natural history, to which we refer the reader for details, as these are foreign to our present purpose. The same may be said of the *vermicula*, which we mention for the sake of method. Three groups are distinguished from each other by Milne-Edwards under the names of *rotifera*, *turbellaria*, and *helminthia;* the first being microscopical animalcules; the second and third, mostly intestinal or parasitic worms. Some zoologists form only two divisions of vermiculæ under the names of rotifera and helminthia, the latter being subdivided into five orders: *i.e.*, *acanthotheca*, *nemertiana*, *turbellaria*, *helminthia propre*, and *cestoïda*. There is still much to learn with regard to these inferior types, and the life history of each species. Van Beneden has shown that different phases of development, in some of the cistoïda, have long been erroneously considered as distinct species; these states or phases are proved to be those of what are called the egg, the *scolex*, the *strobila*, and the *proglottis* or *cucurbitin;* the three latter states were long considered as three different kinds of worm.

As in the lowest class of vertebrata there are two distinct subclasses; *i.e.*, osseous and cartilaginous fishes; so in the lowest class of annulosa, we find two subclasses of vermes; *i.e.*, vermes and vermicula, or annelids and annuloïda. The orders and alliances of these subclasses have been variously arranged by different naturalists, and all we need observe on this head is, that different species are well marked, in many cases, and that is most important. Families and tribes may be variously grouped together, in larger sections, without much inconvenience, until more is known of all the characteristics of each family and species.

PHYSIOLOGICAL CHARACTERISTICS OF ARTICULATA.

The habits and instincts of crabs and spiders, insects and worms, have been well observed in many cases, and fully described in popular works, such as those of Kirby and Spence, the two Hubers, father and son, and other writers of eminence in this department. The study of this realm is more instructive in many points of view than that of any other. Like all the secondary realms, its physiological phenomena are more diversified and more exposed to human observation, than those of the superior realms. A systematic study of all the leading characteristics of each family and species in each of the four classes, will disclose innumerable aspects of instinctual life and metamorphic evolution. To read descriptions of the wondrous works of instinct in these minor creatures, will become more interesting to enlightened generations, than the most exciting novels of the present day. Everything is curious and strange. The different *types* are very numerous and various; the *radiatory modes of action* in these different types are equally diversified; the *permutations*

of state are remarkable, as well as the *complexity of structure;* the difference of *sexes* and development is very strange; their *modes of reproduction* are still more wonderful; the *alimentary constitution* of the different tribes and families, is more diversified than that of higher animals; and the *alimentary modes of action* much more various; of different *temperaments*, very little is yet known; but *vascular modes of action* are known to be more diverse and curious in these types, than in those of any other realm. It is, in fact, a world of wonders without end, in which the active mind may find delight, when satiated with all worldly pleasures.

We cannot enter into all these questions, but we may quote a few very interesting pages from the *Rambles of a Naturalist*, as these will give a general idea of the curious phenomena of embryonic evolutions and metamorphoses.

"In the two kingdoms of nature, epigenesis, or *successive formation*, is the great law which presides, not only over the development, but over the very organisation of germs. Buds, bulbils, seeds or eggs, all reproductive bodies, in fact, are produced from a preexisting individual being, which elaborates them from its own substance, under the influence of vitality, and in consequence of phenomena of nutrition and secretion similar to those from whence result all the other products of the organism. At first imperfect, these germs are successively completed, and only become capable of fulfilling their important functions after they have attained to *maturity*. Some possess in themselves all the vital activity that is necessary for their development, in which case, properly speaking, there is neither father nor mother; others, on the contrary, require the intervention of a special agent, and here first appear distinct sexes which concur in the reproduction of their species.

"In the plant, as in the animal, the female secretes a

germ that must be fertilised, while the male produces the fertilising agent. From the contact of these two elements there results a new individual.

"In the animal and the plant the bud is *living* because it is simply a portion of its parent. Again, in the animal or plant the bulbil is *living*, because, when separated from its parent, it grows and is developed. The seed and the fertilised egg are equally *living*, although both may, for a more or less considerable length of time, present all the appearances of inert matter. Is the egg which we keep for house-purposes *dead?* By no means, for if it were placed under a hen that was sitting it would give birth to a chick. Were the cereals which were found in the tombs of Thebes *dead?* By no means; for when they were thrown into the earth they germinated and produced plants similar to the progenitors, which had disappeared from the face of the earth for thirty or forty centuries. In both cases life was in a *latent* condition, and required for its manifestation a concurrence of favourable circumstances."

Here we may pause to ask what is meant by "life in a *latent* condition"? Is it not certain that man would die if deprived of food during some ten days or less? Is human vitality, therefore, *latent* in the food which is necessary to sustain human life? Or is not the life already in the man, who uses the food to build up the body as fast as it is wasted by combustion? In this case, at least, the already existing principle of life in man is necessary to convert the *latent* physical forces of matter in the food into living tissues of the body. What, then, can the egg be more than a fitly organised substance for a living principle of force to convert into the tissues of an organism? But whence comes this living principle of organising forces? That is the question which is not clearly answered by the words "life in a *latent* condition," already in the

egg, as here supposed, and requiring for its manifestation a concurrence of favourable circumstances. There can be nothing but physical force latent in the egg. The living form of organic force must be somewhere else, in a latent or an active state, waiting for a favourable opportunity to convert the substance of the egg into tissues and organs, as an animal of any kind waits for an opportunity to seize proper food and convert it into bone and muscle. But to continue the quotation.

"The observations which I have made on the hermellas throw considerable light upon some of the difficult points in question.

"On the coasts of Spain (in the Bay of Biscay) which are so violently beaten by the waves, we often observe small hillocks of sand pierced by an infinite number of minute openings half covered by a thin projecting margin. These mounds are either found behind some large rock or in some deep fissure, although occasionally they are fixed on an entirely uncovered point. These little hillocks or mounds, which look very much like a thick piece of honey-comb, are in reality villages or populous cities, in which live, in modest seclusion, certain tubiculous annelids known by the name of hermellas,—creatures as curious as any that fall under the notice of the naturalist. Their bodies, which are about two inches in length, are terminated anteriorly by a bifurcated head bearing a double bright golden coloured crown of strong, sharp, serrated silken threads. These setæ replace the calcareous or horny operculum which, in the ordinary tubicula, similarly serves to close the orifice of the tube. These brilliant crowns are the two sides of a solid door, or rather a true portcullis, which hermetically closes the entrance of the habitation when, at the least alarm of danger, the annelid darts within its house of sand. From the edges of the cephalic opening issue about fifty or sixty light violet-

coloured slender filaments, which are incessantly moving about like numerous minute serpents. These are so many arms which can be lengthened or shortened at will, and which, seizing the prey as it passes, bring it into the hollow funnel-shaped mouth at the base of the depression. It is by means of these arms that, one by one, the grains of quartz or hard limestone are collected and put into their proper places, to serve in the composition of the tubes, the different parts being solidly cemented together by a sort of mortar-like mucosity furnished by the animal itself. On the sides of its body appear little projections, whence issue bundles of sharp and cutting lances or broad fans, serrated like semicircular saws. These are the feet of the hermella. Finally, the back is furnished with cirrhi recurved like sickles, whose colour varies from dark red to grass-green. These organs represent the branchiæ, which, by an exception hitherto found to be unique in this group, are distributed over every ring, instead of being united to the head, like the petals of a flower.

"Their internal organisation is not less remarkable. These singular animals realise in their actual anatomical details a theoretical view which might hitherto have been justly regarded as a mere abstract idea.

"In the articulata generally the two sides of the body are similar to one another; so that these animals may be regarded as formed by the reunion of two symmetrical halves cemented together along the median line; and attempts were long since made to confirm this view by the study of their embryology. Newton, the distinguished English comparative anatomist, had shewn that in the young myriapods the abdominal nervous centres are developed in two halves, which become subsequently united. I had made a similar observation in respect to a *eunice sanguinea*, which was in the act of reproducing the posterior segments of the body which had been lost by some

accident; but no adult animal had hitherto been met with which presented any very apparent traces of this original division. In the hermella, however, this division exists throughout the greater portion of the body. Throughout the whole length of the abdomen the muscles, vessels, and nerves, are double; and the two halves are only held together by the skin and by the digestive canal, which is single. Here, then, the annelid is actually cleft in two. Both before and behind all parts of the muscular and vascular apparatus meet along the middle of the body; but the ventral nervous system remains divided from the one extremity to the other, and its two halves only communicate together by delicate threads or exceedingly thin bands."

The embryology of the hermella is not less curious than the adult form and structure.

"On leaving the body of its mother, the egg of the hermella is composed, like all perfect eggs, of four distinct parts; that is to say, of a yolk or vitellus, a germinal vesicle (vesicle of Purkinge), placed in the interior of the yolk, a germinal spot enclosed within the vesicle, and finally of a very fine membrane which envelopes the whole. (In the eggs of birds the white, or albumen, and the shell, are merely accessory parts which are formed in the oviduct after the actual egg has left the ovary.) The germinal spot and vesicle are two minute, transparent globules; while the yolk is formed of very minute, opaque granules united together by a perfectly diaphanous *matrix*.

"If we throw one of these eggs into sea-water in which some of the male organic corpuscles are moving, we shall see, after a few moments' immersion, that it has become the seat of a condition of vital activity which may be easily watched through the microscope. A mysterious force seems to mould these elements, blending them together on all sides."

It must be a very mysterious force, having power to organise a special type of being; but the author does not stop to inquire what kind of force it is, nor whence it comes. Does it come of the fortuitous concourse of atoms, or is it an invisible form already created, with power to incarnate itself whenever the proper substances and the conditions are prepared for its physiorganic operations? Is there no world of existing forms and forces but that of visible matter? What force causes the organs of the human body to move? What force directs the movements? There is a living principle of force which moves the organism after it is formed, and the same living principle of form and force must move the matter in the metamorphic evolutions of the organs from the substance of the egg to the complete organisation of the living form. But to continue.

"The yolk presents alternating movements of contraction and expansion, the spot and the vesicle successively disappear, a transparent globule escapes from the midst of the vitellus, and then begins the singular phenomenon discovered by MM. Prevost and Dumas. A circular streak is observable round the vitellus, which divides spontaneously first into two, and then into four parts, and goes on subdividing thus successively until it is only composed of very minute globules. (The cleavage of the yolk or vitellus, which was originally discovered by physiologists in the egg of the frog, has since been observed in the ova of all animals that have been investigated under favourable conditions.) In proportion as this cleavage progresses, the granular character of the vitellus diminishes, and finally disappears. The entire mass assumes the appearance of young tissues. At this period we soon begin to perceive a few small filaments which are at first immovable, but speedily begin to strike the liquid with jerking motion. These filaments become more and more multi-

plied, when the young hermella, after having balanced itself for some time, as if to try its nascent organs, suddenly leaves the solid plane which supported it, and throws itself into the liquid under the form of a small and irregularly formed spherical larva bristling all over with vibratile cilia.

"Such are briefly the phenomena presented by the fertilised egg of the hermella. In twelve, or, at most, fifteen hours, this *egg* becomes transformed into an *animal*, which swims about, stops and guides itself, and thus gives evident signs of spontaneity. The same egg, if left in the liquid without being brought in contact with the fertilising element, becomes decomposed in about forty or fifty hours. We must not, however, suppose that it is the less active on this account. The characteristic activity of the first phases of development are manifested here no less than in the fertilised egg. The yolk dilates and contracts, the spot and vesicle disappear, the vitellus undergoes cleavage, and becomes thinner. For the first few hours it is almost impossible to distinguish a fertilised from a non-fertilised egg. In the latter, however, the movements increase in rapidity while they diminish in regularity, and instead of resulting in the *organisation of a new being*, they terminate in the *destruction of the germ*. If, however, we take some of these eggs which seem very nearly decomposed, and bring them in contact with the fertilising corpuscles, their movements will slacken and become more regular; and we may even frequently obtain numerous swarms of larvæ from eggs that have been deposited for nearly forty hours.

"These facts, which I have repeatedly verified, appear to me to be thoroughly conclusive. They teach us that the movements, which have their seat in the egg immediately after its appearance, are entirely independent of fertilisation. The disappearance of the germinal spot and

vesicle, the oscillations of the yolk and its cleavage, are, in the isolated female element, so many signs of special activity, and of a vitality which belongs to it. When these movements cease, and when the egg becomes decomposed, it is in reality *dead*." (No doubt. But, then, as children say, 'what *deadened* it?' Was it not found insufficient by that 'mysterious force' which wanted something more to work with, in order to complete the process of organisation?)

"Thus the fertilising corpuscles after separation from the male, retain a certain amount of vitality. In the same manner, on their separation from the mother, the eggs possess a special and individual life. Even in non-fertilised eggs this vitality is manifested by spontaneous and characteristic movements, precisely the same as we observe in the case of the male corpuscles. In the latter, all indications of vitality disappear in a comparatively short time, and it is precisely the same in respect to non-fertilised eggs. In the fertilised eggs, on the contrary, vital movements are prolonged, and result in the complete organisation of a living being. The contact of the egg with these corpuscles is not, therefore, to give or to reawaken a life which is already present in the egg, and which is manifested by appreciable phenomena, but rather to regulate the exercise of this force, and thus to secure its duration.

"Under the influence of fecundation, all the parts of the egg of the hermella and of the teredo are changed into an animal. The entire mass of these parts is transformed into tissue, the external membrane becoming the skin of the new being. Here we have, in truth, a *metamorphosis* in the strictest sense of the word. As phenomena more or less similar to those which we have sketched occur in all species, whether oviparous or viviparous, it follows that this expression, which has been proscribed by

evolutionists, ought rather to be generalised and applied to the development of all living beings. Embryology might, properly speaking, be defined as the *science of metamorphoses.*

"The word *metamorphosis* would here assume a general sense, and would designate the succession of epigenetic facts, which produce from the germ, either a perfect animal or plant. Hitherto, however, it has only been applied to those very apparent modifications which are experienced by certain animals after their escape from the egg, and we will therefore employ the term in its usual signification. Even in this restricted sense the phenomenon of metamorphosis is much more common than is generally supposed. It was long regarded as a characteristic of the class of insects; and of the group of the batrachian reptiles, frogs, salamanders, etc., being the only types of vertebrata which present true metamorphosis. At the present day, however, it has been found to occur in a great number of articulata, and in most molluscs and radiate animals. In proportion as this remarkable phenomenon is observed in more numerous and more varied types, it exhibits itself under an entirely new light. For example, it was formerly believed that the object of metamorphosis was always to raise the organism to a more perfect condition. Such is, indeed, the case with the tadpole that becomes a frog, and the caterpillar, which is changed into a butterfly, but not in those cases to which Milne-Edwards has proposed to apply the term *recurrent types*, such as the *teredo*, the *lernea*, etc., where the very progress of the animal seems to result in the organic degradation of the individual. (By the loss of certain organs no longer wanted. Is the human fœtus degraded by the loss of the umbilical cord at birth ?)

"In the case of the teredo, the larva, which at first is almost spherical and entirely covered with vibratile cilia,

may be compared to a very minute hedgehog, in which every spine acts as a natatory organ. It swims in all directions with extreme agility, and this first state continues about thirty-six hours. Towards the end of this time, the external skin bursts, and after being incrusted with calcareous salts becomes a shell, which is at first oval, then triangular, and at last very nearly spherical. While the shell is being formed, the vibratile cilia disappear, but the little animal is not, on that account, condemned to inactivity. In proportion as the external cilia diminish, we observe that another equally ciliated organ becomes developed, which widens and extends in such a manner as to form a large ruff or collar margined with fringes. This new organ of locomotion may be entirely concealed within the shell, or may be extended from it, and acts in the manner of the paddle-wheel of a steamboat.

"By means of this apparatus the young larva continues to swim with as much facility as in its earlier age; but it now, moreover, requires another organ, which enables it to advance upon a resisting plane, as, for instance, to rise along the side of a glass vessel. This is a sort of a fleshy foot, very similar to a long and very mobile tongue, which can be extended and contracted at will. The larva of the teredo possesses, moreover, organs of hearing similar to those of several other molluscs, and eyes analogous to those of certain annelids.

"During this period of its existence our mollusc, therefore, enjoys to a high degree the characteristic faculties of a *living being*. It moves, and is brought in relation with the external world by organs of the special senses. Now, however, comes a last metamorphosis, and this same teredo loses its organs of motion and sensation, becoming a kind of inert mass in which vegetative life replaces almost entirely the active spontaneity of the animal.

"The birth and development of a germ, and the metamorphoses of the being which derives its existence from that germ, are objects which cannot fail to interest all those who are capable of thought and feeling. The crudest facts have in themselves often an immense interest in consequence of the questions which they raise or solve ; but even beyond the modifications of form and the transformations of matter, it is impossible not to recognise something infinitely superior. Everywhere in these phenomena *life* appears as a distinct force, acting with one special object which could not be attained by any other agent, giving rise to germs and fashioning each one according to its species. While it is always one and the same in its essence it is infinite in its manifestations, enveloping inorganic and dead matter in the rich mantle of organised creation. We may recognise this force by its effects, but we shall, doubtless, always remain ignorant of its nature. Here we are almost assuredly touching upon the profoundest mysteries of this world ; for beyond this primary cause there is nothing but *the Cause of causes*,—there is nothing but God."

In this last sentence, the author concludes that God performs a special act of creation in every case of the procreative reproduction of a species. It may be, that God creates innumerable living forms in a world invisible to mortal eyes, and that these living forms incarnate themselves, by the intervention of their fellow species, in this natural world, preparing germs exactly suited to the process of metamorphic evolution or incarnation. This view of the case suggests another question with regard to the phenomena of hybrid procreation by contiguous species, and suspended animation with periodical revivals in the infusorial tribes ; but more fit opportunities for discussing these questions will occur in other chapters.

All physical organisms originate in germs or ova, and

pass through successive stages of formation by a process of metamorphic evolution or epigenesis; but the development of germs is very different in organisms of different species, families, and orders in one class or realm, and still more different in the types of different realms. The differences of external forms have always been familiar, but modern science has discovered numerous and very curious points of difference in organic structure; more especially with regard to the existence of a nervous system in many of the lower types, which were formerly supposed to be devoid of nerves. "Cuvier had only detected in the gasteropodous molluscs a very small number of *ganglia* or central masses, which convey both sensibility and motion to every part of the body; but Mr. Blanchard has since discovered in this apparatus a most unexpected degree of complication, and shown that in certain species these ganglia are very numerous; and that, instead of five or six hitherto observed, there existed nearly thirty of these masses. The observations of Lyonnet on the goat-moth, and of Strauss-Durckheim on the cockchafer, have shown that the organism is fully as complicated in the class of insects as in the largest animals. Mr. Blanchard has extended his investigations on the nervous system to the intestinal worms (helminthia), which are sometimes developed in the very midst of living tissues, in the muscular substance, in the brain, and in the ball of the eye. 'In proportion as we carefully study the most apparently degraded animals,' says M. A. de Quatrefages, 'we discover more and more traces of a nervous system in the greater number of them.' Cuvier admitted its presence in the first three divisions of the animal kingdom, but scarcely, if at all, in the radiata. Tiedeman, Costa, and Krohn have since demonstrated its existence in the echinoderms, to which belong the star-fishes; while Ehrenberg, Grant, Milne-Edwards and Agassiz have de-

scribed it in the acalephoe (jelly fish). M. de Quatrefages has discovered it in the nemertes and plenarias, animals very nearly allied to certain intestinal worms, although they live in water. Fully half the radiata, and all the worms, therefore, possess nerves as distinct as those of higher animals.

"In proportion as zoologists have more thoroughly investigated the mysteries of the inferior world, organisation seems to have grown more complicated, and to have assumed more unexpected forms. Let us beware, however, of falling into an opposite extreme. After having admitted, without sufficient proof, the organic simplicity of the lower animals, and discovered our mistake, we must not conclude from a few already known facts that they all present an equal degree of complication. At the lowest point of the zoological scale, there exist beings in which all the vital acts are accomplished simultaneously, and in the same manner, over all portions of the body, and whose organs appear to be fused together into one homogeneous structure.

"In the living sponge, a sort of semi-fluid varnish covers, with a thin stratum, that horny and more or less solid skeleton, commonly called the sponge. This varnish is the actual animal; that which we call the sponge is merely the skeleton. The amœba, which is still more simple, appears to be nothing more than a drop of living varnish, endowed with locomotion, but not having even a determinate form. The eye, when aided by the microscope, may see these animals flow together into a mass, as drops of oil would flow over the slide, while they present the most diversified and irregular forms. M. Dujardin has shown us that the rhizopods are animals covered with a shell, but whose body is without definite organisation. A gromia and a milliola, before they climb up the polished side of a glass vessel, form for themselves, on

the instant, and at the cost of the substance which composes them, a sort of foot, which stretches out, and becoming elongated, affords them a point of support: as soon as they no longer need this assistance, this temporary organ returns into the common mass, just as a thread of viscid matter returns to the substance from which it has been drawn out. Between these extreme points of the animal scale and the more complex animals there exist, no doubt, many intermediate forms: for, as Linnæus has said, nature does not make any sudden bounds, and always proceeds by insensible gradations."

"While modern science has discovered in the lower types of organism, and more especially in worms, a most unexpected organic complication, it has also recognised the fact, that the superior realms themselves comprise inferior types—degraded forms, even, of mammals, birds, reptiles, and fishes. The group of myxinoides, lampreys, and more especially the amphioxus, leave no doubt on this subject, as far as the fishes are concerned.

"While we have no difficulty in asserting most definitely that it belongs neither to the articulata, the mollusca, nor the radiata, it scarcely merits the name of a vertebrate. It has hitherto been admitted, that the essential characters of this division of the animal kingdom are the presence of a vertebral column, a brain, a heart, and red blood, yet the amphioxus possesses neither heart nor brain, properly so called, nor any distinct vertebral column, and its blood is entirely colourless. The impulse necessary to make the nutrient fluid pass through the circulatory circle, is communicated to it by large vascular trunks. The blood resembles that of the molluscs. The vertebral column is represented by a cartilaginous stem, entirely composed of cells, and extending from the head to the tail. The brain, which is not protected by the slightest appearance of a cranium, is only distinguished

from the spinal cord by the direction of the nerves which issue from it. The eye is entirely enclosed in the interior of the tissues: but, owing to their perfect transparency, it is probable that the functions of the organ of sight are not less perfectly accomplished. This diaphanous character of the amphioxus enables us, moreover, to ascertain that it possesses a mouth, which belongs rather to the mollusc than the fish, together with a circulatory apparatus and a mode of digestion which reminds us of similar organs in the annelids.

"The attentive study of the amphioxus shews us a permanent condition which recalls, in certain respects, the transitory embryological condition of the most perfect animals belonging to the same type. Thus, during the first periods of its development, the embryo of the ordinary fish—such as the salmon, for instance—possesses peculiarities of organisation which remind us of those we observe in the amphioxus; but whilst these peculiarities are persistent throughout the whole life of the latter animal, they are soon effaced in the young salmon to give place to other definite characters. The embryology of the annelids exhibits precisely similar facts: thus, for instance, in the early period of its existence, the larva of the terebella closely resembles a nemertes. We speak here of *partial resemblances*, not of *identity*. A young terebella is at no time an adult nemertes, nor can a salmon ever have been an amphioxus.

"Here we find a manifest accordance between the results furnished by anatomy and those obtained from embryology. All germs resemble one another in the first period of their development, and they successively differ from each other in proportion to the advanced condition of their development; and consequently the beings which are evolved from these germs deviate from one another in proportion to the degree in which they may be consi-

dered as representatives of their type. Consequently also the series resulting from these successive phases of development will be widely separated at their summits, but will approximate at their bases; and hence the relations borne by one series to another will be exhibited by the inferior, but not by the superior animals."

We must qualify the statement of M. De Quatrefages, as likely to mislead the mind of the reader notwithstanding the general correctness of the descriptions given above. It is a mistake to suppose that there is really less difference between one germ and another of a different kind than between one adult animal and another of a different type; but our present means of observation and analysis do not enable us to discover the differences as easily in one case as another. The seeds of oats and barley, pears and apples, are really as different from each other as the full-grown plants to which these fruits and seeds belong. The eggs of ducks and pheasants are as distinct in every essential form and feature of their so-called homogeneous substance as the full-grown birds which lay them. The germs of every plant and every animal are just as distinct from each other as those here named. The metamorphic evolutions of all germs are different in accordance with the nature of the germs from which they spring; and all the stages of development are as markedly distinct, in different types, as are the germs and the adults to which they respectively belong. There is, nevertheless, a certain law of similarity in all organic germs, metamorphic evolutions, and adult types of organism; and, moreover, there is a certain unity of plan in all the inorganic and organic realms of epicosmic nature, as we have shewn in this volume; but there is manifest diversity as well as unity in the organic constitution of these realms, even from the highest collective unity down to the minutest elementary combination of their indivisible units.

In a broad, general view of organic diversity of form and structure we may easily perceive that mammals are the highest and fishes the lowest developments of vertebrate organisms; that man is the highest mammal, and the amphioxus the most rudimentary fish. Articulata are the highest class of their realm, worms the lowest; crabs are the highest types of articulata, helminths the lowest types of worms; cephalophora are the highest class of molluscs, tunicata the lowest; cephalopods are the highest types of their class, polyzoa the lowest forms of the lowest class. Holothuria are the highest class of radiata, protozoa the lowest; chirodota is probably the highest known type of holothuria, amæba the lowest form of protozoa. Between these extremes in every realm there are numerous degrees of similarity and of diversity more easily discernible in one case than another by ordinary means; but not more really distinct in one stage of metamorphic evolution than another, in one germ than in another, in one adult than in another, if we had equal powers of observation and distinction in all cases. And yet all possible diversities of forms and forces necessarily belong to one sole plan of unity, without which nature would be without a law.

OUTLINES OF MOLLUSCAN UNITY.

The natural history of mollusca is yet but little known; and, were it more advanced, the comparative embryology, physiology, anatomy, and histology, of the whole realm would be a work of too much magnitude for this short notice. An outline of individual anatomy and collective unity is all that we shall deal with here.

In a mollusc of the highest type, such as the dibranchiate cuttlefish, there are seven systems and five inosculatory senses more or less developed, with connective tissues

of analogous structure and functions. There is a vascular system with a double circulation (pulmonary and systemic), a digestive system of a complex structure, a generative system of the oviparous type, a ganglio-nervous system, the rudiments of an osseous system, a muscular system, and a cutaneous system. There may be no proper sense of smell, but there undoubtedly is a branchio-sensitive apparatus, however rudimentary in structure, sufficient to distinguish wholesome from noxious gases for respiration. There is a distinct buccal apparatus, and some degree of a sense of taste. There are natural inosculatory organs in connexion with the generative system. Organs of sight and hearing are also found in the naked cephalopod. Testaceous cephalopods have no recognised organ of hearing, nor have any of the lower types, although some degrees of vibratory sense may be attributed to all.

We have, then, in the perfect mollusc a rudimentary repetition of all the main systems and senses of the vertebrata, and therefore we may look for a corresponding number of alliances and families in the organic unity of the whole realm; the history of which, however, is too little known at present to enable us to trace with perfect accuracy the order and degrees of biologic unity in all its parts. Zoologists differ in their arrangements of classes and sub-classes, alliances and sub-alliances, genera and species; nor are they likely to agree on all these points until more is known of the life-history of all the species as well as of the principles of natural organic method. The following synopsis of collective unity is, then, a mere approximation to the taxionomic view of all the families and classes of this realm.

De Blainville gives the best general arrangement of mollusca, but not of the intermediate subdivisions. Cuvier establishes three classes of cephalophora, namely,

cephalopods, pteropods, and *gasteropods;* the latter he subdivides into nine orders, according to peculiarities of structure and locality in the respiratory organs. This is not exactly in accordance with the divisions of the organs in the individual type, as there are not three classes and nine orders of apparatus in the body of a mollusc. We must lower the rank, and alter the names of these divisions, as well as the order of arrangement.

It is not without due hesitation that we venture to meddle with the names and definitions of eminent working naturalists, who have laboured earnestly in this department; nor do we, indeed, really interfere with their distinctions and divisions, although we may, to some extent, modify the ranks of orders and alliances. In doing this, however, we mostly accept one or other of their different views, and never differ from them altogether. Cuvier, De Blainville, and the naturalist who has arranged the synoptical table of mollusca published by the Society for Promoting Christian Knowledge, are our guides, and one or other of these we follow in all cases. Where they are undecided, we do not pretend to settle any point. The writer of Knight's *Pictorial Museum* observes, in speaking of the various subdivisions of volutidæ, "From such a number of genera, we may easily form some idea of the overwhelming multitude of species which the family volutidæ contains. The study of such a family without instituting sections, even on artificial grounds, would be a work of immense difficulty. Nor do our observations apply only to volutidæ; they are applicable to every family of gasteropodous molluscs. Nor is this labour decreased, when we come to review the various systems which different writers have adopted, and the opposite views which they entertain. Hence we find genera located first in one section, then in another, or utterly dismembered by one writer, who scatters the

species abroad, forms many genera from them, or assigns them to genera already established; while another writer, perhaps, will more or less completely reunite them, and place them in a new situation. Look, for instance, at the capulidæ, or *les capuloïdes* of Cuvier, which, in that great naturalist's opinion, comprehends five genera, of which four are dismembered from the limpets (patellæ). Instead of five genera, however, he gives the characters of ten, of which we find five, including species which have been regarded as belonging to the genus patella. In a note he says, 'M. de Blainville en met la plupart dans ses paracéphalophores hermaphrodites non symmétriques ou calyptraciens; mais ils me paraissent tous dioïques."

These disagreements with regard to genera and species of mollusca, are not of much importance in a more general point of view, such as that with which we are occupied, but they leave us some degree of latitude in forming our organic parallels, apart from their ideas of arrangement.

In forming natural alliances and orders of mollusca, we have the same organic law to guide us as in forming those of vertebrata, where the first main type is placed in correspondence with the nervous system, and the second with the vascular. Now these have many points in common in the vertebrate bimana and quadrumana, whereas we find few points of likeness between the highest mollusc, or cephalopod, and any other type, unless it be with pteropods, which also differ from nearly all gasteropods, excepting perhaps the opisthobranchiata and the heteropoda.

In the class cephalophora, the cephalopoda can only form one general division or alliance: the pteropoda another. Gasteropoda form numerous alliances and orders, very nearly in the manner indicated by De Blainville or by

Cuvier, though not in the same order of rank and degree. The families remain the same, but not the general alliances. The difference, however, being one of name and rank alone, does not disturb the natural affinities, while it aids the memory in forming parallels. In these we form an opisthobranchial order; a heteropodal, a buccinoïdal, and a conidal; a scutibranchial and a cyclobranchial; a cephalopodal, a dentalial, a paludinal, a pulmonial, a pyramidellian, and a turbinate order. The pteropoda we class as an inferior family in the first of these general divisions. By this means we have seven alliances, or twelve orders, of cephalophora, corresponding to the seven systems and five inosculatory senses of the individual mollusc, as in the parallel divisions of the highest class of vertebrata. In both realms the connective classes hold inferior rank, and their subdivisions run parallel with the connective tissues of the individual organism.

These are not, perhaps, alike in vertebrata and mollusca, but they bear like names in each, and serve a similar connective purpose. Glandular tissues, lubricative internal tissues, and areolar connective tissues are found in the mollusca as well as in the vertebrata, and three connective classes of acephala run parallel in the collective realm with these connective tissues in the body. De Blainville calls these "*lammellibranchiata, palliobranchiata, heterobranchiata,* the two latter being the *brachiopoda* and *tunicata*" of Cuvier, who divides the first into thirteen families, namely, *pectinidæ, spondylidæ, malleïdæ, meleagrinidæ; mytilidæ, naïidæ, arcadæ, chamidæ, cardidæ; myadæ, solenidæ, pholadæ, gastrochenidæ;* and these may be very naturally classed in four alliances, parallel with the four alliances of glandular tissue, in connection with the vascular, the digestive, the generative, and cutaneous systems. The common names

of these four alliances are *oysters, mussels, cockles,* and *pholads,* or boring and burrowing bivalves. *Oysters* may be classed in parallel with the glands of the pallium and cutaneous system ; *muscles* with those of the vascular system ; *cockles* with those of the digestive system ; and *pholads* with those of the generative system.

The fatty or serous tissues are not conspicuous in the individual mollusc, and the brachiopoda or palliobranchiata form but three simple groups of acephala, namely, "*terebratula, lingula,* and *orbicula.*" The areolar connective tissues of the individual organism are also simple, and the acephalous class of tunicata is more curious than complicated in form and structure. Cuvier divides it into two sections, one containing isolated species, and the other aggregated species. *Ascidiæ* and *salpæ* belong to the first ; *botryllus* and *pyrosoma* to the second. *Tunicata* and *polyzoa* are the names now given to the two subclasses of this lowest class of acephalous mollusca.

The following synoptic parallel between the systems and connectives of the individual organism and the leading orders and connective classes of the realm, will give an outline of the law of biological unity in each ; and this is all we aim at in the present case.

BIOLOGICAL UNITY OF MOLLUSCAN REALM.

Z.	Supernal Forces, etc.	H. *Embryonic supplies.*
		U. Climatic conditions.
		Ω. Alimentary resources.
		O. Physiorganic forces and instincts.
Y.	Comparative Ingesta, etc.	H. *Comparative impregnata.*
		U. Comparative investa, etc.
		Ω. Comparative ingesta.
		O. Comparative blood, etc.
X.	Comparative Exuviæ, etc.	H. *Genetic out-births.*
		U. Glandular excretions.
		Ω. Lubricative secretions.
		O. Necrological exuviæ.
W.	Acephalous Connective Classes.	H. *Extinct acephala.*
		U. Lammellibranchiata.
		Ω. Palliobranchiata.
		O. Heterobranchiata.

VII.	Opisthobranchiata.	H.	*Pteropoda (?)*
		U.	Tectibranchiata.
		O.	Nudibranchiata.
		Ω.	Dermibranchiata.
·7.	Heteropoda.	H.	
		U.	Carnaria.
		O.	Firoliæ.
		Ω.	Atlantidæ.
VI.	Buccinoïda.	H.	*Magilus (?)*
		U.	Buccinidæ.
		O.	Muricidæ.
		Ω.	Strombidæ.
·6.	Conida.	H.	*Mitridæ.*
		U.	Conidæ.
		O.	Cypreïdæ.
		Ω.	Volutidæ.
V.	Scutibranchiata.	H.	
		U.	Haliotidæ.
		O.	Fissurellidæ.
		Ω.	
·5.	Cyclobranchiata.	H.	*Calyptreïdæ (?)*
		U.	Patellidæ.
		O.	Chitonidæ.
		Ω.	
IV.	Cephalopoda.	H.	*Nautilidæ.*
		U.	Teuthidæ.
		Ω.	Sepiadæ, spirulidæ.
		O.	Octopodidæ, argonautidæ.
III.	Dentalia.	H.	
		U.	Dentalidæ.
		Ω.	
		O.	
·2.	Paludinia.	H.	
		U.	Naticidæ.
		Ω.	Neritidæ.
		O.	Paludinidæ.
II.	Pulmonaria.	H.	*Limacidæ.*
		U.	Helicidæ.
		Ω.	Limneïdæ.
		O.	Auriculidæ.
·1.	Pyramidellia.	H.	*Tubulidæ.*
		U.	Turritellidæ.
		Ω.	Pyramidellidæ.
		O.	Scalaridæ.
I.	Turbinata.	H.	*Cerithiadæ.*
		U.	Meliniadæ.
		Ω.	Littorinidæ.
		O.	Turbinidæ, trochidæ.

Physiological Characteristics of Mollusca.—The physiological characteristics of each realm are quite as

much diversified as the structural characteristics, but we cannot, in these brief outlines, enter deeply into questions of physiology, which are well explained in special works of recognised authority. Special *types* of structure, *radiatory modes of action*, *natural permutations* of state, *vibratory modes of action*, various degrees of *complexity of structure*, different kinds of *alimentary constitution*, and *alimentary modes of action*, different *temperaments* in individuals and peculiar *vascular modes of action*, different *sexes*, male, female, hermaphrodite, bisexual, neutral, and various *modes of reproduction*, are met with in different kinds of molluscs. We need not enter into all these questions, but a few words on some of the most striking physiological and structural peculiarities of molluscs, compared with those of other invertebrate organisms, will give a general idea of the immense diversity of forms in nature, and the wonderful modulations of creative power, adapting every creature to the various conditions of existence. Here, again, a few short pages, quoted from the *Rambles of a Naturalist*, will give us an idea of the different modes in which the organs of sight, for instance, are distributed in the lower types of annelids and molluses.

"The splendid discoveries of Ehrenberg revived in 1830 a discussion of originally a much more ancient date. Among naturalists, some adopting the views of the illustrious Berlin microscopist, maintain that even the smallest animals, those, for instance, which in our scientific classifications are placed in the very lowest position of the zoological scale, present an organisation which is fully as complicated as those of the higher animals. Others, on the contrary, following the steps of the celebrated founder of the *natur-philosophie*, maintain with Oken, that the organisation is simplified in a progressive manner, the lower we descend in this scale ; so that entire groups,

composed to a certain extent of rudimentary animals, are almost entirely devoid of organisation. The latter class of observers agreed with Raumer in regarding the medusæ, for example, as nothing more than *masses of living jelly*, whilst the planarias and the greater number of intestinal worms, in their estimation, consist of little else than *parenchyma*. In their eyes this simplification of the organisms was carried to such an extent, that whole classes of animals were regarded as altogether devoid of a nervous system.

"Various works published during the last few years present the subject in its true aspect. Many points of detail still need elucidation, but it may be stated, generally, that wherever we study, even the lowest animals, with care and exactness, the results of our investigations will show us that even in their case, a very decided *organic complication* is apparent. The advocates of *organic simplicity* are daily losing ground, and are unable to defend themselves except by having recourse to the negative results yielded by the infusoria; that is by beings whose excessive minuteness places the majority beyond our means of investigation." (Professor Balbiani has recently proved that the infusoria are much more complex in structure than had been supposed; and that they propagate their species by genetic modes of action analogous to those of other minute creatures; so that the theory of heterogenesis is now disproved.)

"Amongst the most warmly discussed points of fact or theory in this controversy, we must place that of the existence of distinct organs of the senses, and more especially of eyes, in a great number of animals which belong to the three divisions of the mollusca, articulata, and radiata.

"Ehrenberg had regarded as organs of vision certain coloured points which are met with in the margin of

the umbrella in medusæ; at the extremities of the rays in the star-fishes; in the head, among the annelids, planarias, rotifers, etc.; and at one of the extremities of the body, in certain of the infusoria. The accuracy of most of these statements was denied in the most positive manner, although often very unjustly. In proportion as these creatures have been more profoundly studied, in the case of those animals whose size rendered them accessible to our methods of examination, it was found that the greater number possessed true organs of vision. The most abundant evidence on this point has been contributed by naturalists of every European nation.

"The annelids more especially furnished me with a very striking example of this fact. One of the species, which lives in the Sicilian seas, possesses eyes which are almost as complete as those of a fish. I have succeeded in enucleating the crystaline lens, and in examining it separately; and I found that when it was placed upon a piece of thin glass which received the parallel transmitted to it by a plane mirror, it formed perfectly acromatic images. These images, repeated and magnified by the microscope, enabled me to distinguish with perfect clearness the very smallest details of the neighbouring coast, and by means of the crystalline lens of an annelid my microscope was thus converted into a telescope.

"The opposition which Ehrenberg met with was even more strongly marked when he announced that he had discovered an annelid, the amphicora, which carried, at the *end of its tail*, eyes which were perfectly similar to those which were upon its head. How, it was asked, was it possible that eyes could exist at so great a distance from the brain, and without having any probable connection with it? The question was thus made a general one, and consequently acquired a very high degree of physiological importance. It was no longer sufficient to ascertain whether

eyes did, or did not exist, but it was now further necessary to decide if any one portion of the nervous system, excepting the brain, could become the seat of sensorial perception.

"If by the word *eye* we must understand an organ which is always the same, and everywhere similar to that which we find in man, or in birds, then annelids, nemertes, planarias, and medusas are certainly blind animals, but, like every organic apparatus, the visual organ may be simplified and *degraded*, without on that account changing its nature. Even in this state of degradation it maintains its fundamental parts, and these parts are generally easy of recognition.

"Although destined to fulfil an entirely *physiological* function, the eye is a true physical apparatus. It always consists of a *camera obscura* in which a *converging lens* concentrates the light, and throws the image of external objects on a *screen* placed in its focus. But here the lens, instead of being formed of inert matter, is organised, and is known as the *crystalline lens*. The screen is also living, and bears the name of the *retina*, and it is through the latter that the impression received from images is transmitted to the brain. However varied may be the degree of complication in an eye, its fundamental part always consists of a crystalline lens and a retina. We are, therefore, bound to consider as a true eye, every organ which possesses these characteristic elements; for it could not fulfil any other function but those of which we have spoken. To decide this general question advanced by Ehrenberg, and to ascertain whether, in fact, the visual organ can exist elsewhere than in the head, we must necessarily find in the amphicora, and in every other animal presenting analogous facts, the crystalline lens and retina of the eyes. The term crystalline is here used to express generally the whole refractive apparatus of the eye.

"On the coasts of the Channel and of Sicily, I had found many annelids allied to the amphicora, and bearing on the posterior extremity of their bodies the coloured points in question. In some of these species that I had discovered, these coloured points were, moreover, strangely multiplied. There were several of them on the head, four at the extremity of the tail, and two on each ring of the body. This multiplication seemed to me to present in itself a very serious objection to the views of Ehrenberg. How was it possible to believe in such a profusion of visual organs? Yet, the study of the living animals seemed to confirm this determination. I saw the tail fulfilling all the functions of the head, and this with evident proofs of spontaniety and intelligence. In moving, the tail went first, explored the objects without touching them, and turned aside from obstacles that lay in its path: in a word, it acted as if it were the seat of distinct vision, and as if it were directed by a clear will. Nevertheless, notwithstanding the many hours devoted to these observations, I was unable to discover either a crystalline lens or a retina; and hence my conviction in reference to so delicate a question as this, could not be conclusive.

"At length, among the corallines, those small algæ which cover the rocks with their closely compressed tufts as the moss mantles over the stone, I discovered the polyophthalmians (*polyophthalmia*). Here there was no longer any room for doubt; the fable of Argus was realised before me on the most incontestible evidence. Imagine to yourself a nearly cylindrical little worm, of a golden yellow, about an inch in length, and armed with two rows of setæ, whose length increased from before backwards, and you may, perhaps, form some idea of the aspect presented by polyophthalmians in a state of repose. In the sand where it passes its life, this animal moves with incredible rapidity, by means of the general contrac-

tions of its body and the setæ which serve it in place of feet; but as soon as it wishes to swim freely in the water, or merely to place itself in such a manner that the little animals on which it preys may be within reach of its mouth, two large ciliated structures, which are placed on the sides of its head, are protruded, and act like the two paddle-wheels of a steam-boat.

"With the view of directing its course, the polyophthalmian is provided on its head with three eyes, each of which is furnished with two or three voluminous crystalline lenses, very easy of recognition. Besides this, on each side of the rings of its body, there appears on either side a red point, very similar to those of the amphicoræ. On dissection we find that each of these points receives a large nerve issuing from the ganglion or ventral nervous centre corresponding to it. By the help of the microscope, we can see that this nerve penetrates into a mass of pigment which encloses a spherical crystalline lens, and we now see that the textures lying before it have undergone a modification by which they are rendered more completely and equably transparent. In a word, we can no longer doubt that these red points, placed on the sides and along the whole length of the body, are true eyes, receiving their optic nerves from the abdominal nervous centres, and having no direct connection with the brain.

"This result, however strange it may appear, is not the only one of the kind by which modern science has been enriched. The Mollusca furnish us with several facts of the same nature. Most of our readers are no doubt acquainted with the pecten, commonly known as *St. James's* or the *pilgrim's shell.* The animal (a "headless mollusc") which inhabits this shell somewhat resembles the oyster, and possesses, like the latter, a mantle or thin covering of living tissue, which lines the interior

of its habitation. The pecten, which is as restless as the oyster is sedentary, possesses organs of vision, and these organs are not placed upon the head, nor are they connected with the brain, but they occupy the margins of the mantle, and derive their optic nerves from the great ventral ganglion." The existence of these eyes appears to have been long known, but no detailed anatomical description of them was published until 1840, when they were first made known in Germany. I have been able to verify these observations at different times, and I have detected in these eyes in the mantle of a mollusc almost all the parts which are present in the eyes of a mammal, including even eyelashes and eyebrows, which are here represented by fleshy cirrhi, which surround and protect the delicate organ of vision.

"Three German naturalists—Grube, Krohn, and Will—have extended these researches to other genera of acephalous molluscs, and they have detected a similar organisation in the spondyli, tellinæ, pinnæ, arcæ, pectunculi, etc. In the presence of such precise and abundant evidence, our observations on the polyophthalmians lose their apparent improbability. Indeed, the multiplication of eyes, their lateral position, and their relations with other nervous centres than the brain, are perhaps less singular in this little annelid than in the molluscs of which we have just spoken.

"Certain star fishes have a well-characterised eye at the extremity of each of their rays, while the nemertes and the planarias are often provided on the lower and upper surface of their heads with fifty or sixty, and sometimes even a larger number of distinct eyes."

It may seem strange, at first, that eyes should exist on the external skin of different parts of the body of an animal: but what is there less strange in the sense of touch, situated in every part of the skin, and more parti-

cularly in the palmar surfaces of the extremities? Is not the sense of feeling as distinct as the sense of sight? and does not the degree of consciousness depend upon the living principle of instinct or intelligence, in both cases, more than on the mere sensation of the special organ? Are there not "eyes which see not, and ears that hear not?" and do we not, all of us, sometimes find ourselves so perfectly inattentive to sights and sounds which fall upon our senses, that we neither see the things nor hear the sounds? Do all the senses of the body communicate directly with the brain? Do all the nerves of the skin and mucous membranes go directly to the brain? Do all degrees of instinctual consciousness reside necessarily in the ganglionic centres called the brain? Have headless and brainless molluscs no degrees of instinctual consciousness? Has the evergreen oak, which grows aslant to find the light of the sun, rather than grow upright in the dark, under the shadow of a larger tree—has this tree no organic sensation of the solar rays, which informs its vegetative feelings of the baneful influence of the privation of the light? There is evidently a graduated scale of sensation and vegetable or instinctual feeling, accompanied by attractive or repulsive action and reaction, in all the organic realms, from the lowest types of vegetable organism, up to the literally conscious instinct of animals, and the still more conscious intellect of man. Sight is not necessarily an organ of sense, peculiar to intelligent beings, more than any other physical organ of sensation; nor is it necessarily connected with intelligence more than with mere instinct; nor is it more essential to any degree of consciousness or attractive and repulsive vitality, than is the sense of touch or temperature. Light, heat, and electricity or magnetism, affect all organisms in various degrees, healthfully or otherwise, and are attractive or repulsive to the physical idiosyn-

cracy of the organic body, in proportion to the natural laws of adaptation, in all cases.

OUTLINES OF RADIATE ORGANIC UNITY.

Not much is known of the comparative embryology, physiology, histology, and anatomy of radiata. The highest individual organism is very simple, and the lowest is naturally still more simple; so that we may look in vain for much diversity in the collective families and orders, where the individuals themselves are so far from being of a very complex structure. There is, however, one aspect of diversity which is peculiar to the lowest types of radiata: and that is the diversity of functions performed by a very few homogeneous tissues. In the lowest *protozoa*, the body is composed entirely of a kind of jelly; and in cœlenterata there is little more to be distinguished than a double fold of membrane, forming an external and internal skin, commonly called "ectoderm" and "endoderm." And yet functions of secretion and absorption, digestion and circulation, sensation and motion, are performed by these simple tissues, apparently more diversified in form than differentiated in development. In echinoderms the organisation is more complex than in cœlenterata; and the holothuria are higher than radiate echinoderms.

In vertebrate animals and man there are special organs for special uses, though several kinds of tissue are associated in each organ and each system. The complexity of structure is, however, almost as great in one type as in another of the same class, even in this higher realm; and the diversities of form are more remarkable than those of organisation. It is more to differences of

form and function, then, that we must look for diversity in groups of animals, than to differences in the tissues and complexity of structure in the body. This rule applies to the highest realms of animated nature as well as to the lowest; and therefore we may expect to find it as manifest in the radiata as in the vertebrata. Diversity of function is more important than diversity of form and structure together, for the one may be considerable, where the other two are very unimportant. It is the life of the animal which gives it rank and character more than the organisation. And this is a universal principle. Let us take a view of life in human nature as a prominent example of this law.

Individuals are much alike in all the races of mankind; but the functional vitality is very unequal in different societies. We may easily recognise four great distinctions on the globe, by comparing Christian nations with Mahomedan, and these again with pagans, such as the Hindoo and the Chinese. Lower still than these are the negro races, and other savages, in various portions of the globe. Fetichism, Brahmanism, Buddhism, Mahomedanism, and Christianism are the most characteristic religions of mankind, in these very different states of civilisation and national vitality, where all the individuals are alike in bodily form and structure.

There are slaves and freemen, petty chiefs and kings, amongst the negroes, but nearly all the functions of social and industrial life are performed by each individual, as in a mass of polypes. There is less diversity of occupation among pagans; a higher social order in Mahomedan societies; and a higher still in Christian nations.

These distinctions of society may be compared to the animal realms of nature, which rank one above another in complexity of structure and diversity of function. And, as each realm contains four classes of a graduated

rank, so each society may be subdivided into four classes of a descending scale, from the upper to the middle, the lower, and the lowest. And here again we may observe a difference analogous to that in question: for in a household of the highest class in civilised society the duties of domestic labour are divided into many specialities, allotted to different individuals; while, in one of the lowest class, one person has to do them all. A poor man's wife is cook and housemaid, nurse and parlour maid, lady's maid and laundry maid, mistress and servant-of-all-work, not to mention baking and brewing, wood cutting, and many other incidental duties, which fall to the lot of one individual inmate of a poor man's cottage in the country. The husband has almost as many occupations as the wife in such conditions of society.

In the vertebrate realm there are special systems and organs for each special function of the organism; while in the realm of radiata there are but few tissues and organs for many different functions. Skin, muscles, bones, and nerves: vascular, digestive, and generative systems, are set apart for their respective uses in the one; but all these functions have to be performed, in a rudimentary manner, by a very few varieties of tissue in the other. In protozoa, a kind of sarcode jelly performs the uses of nutrition and secretion, reproduction and contractile motion; while, in higher classes of the radiata, a sort of complex membrane, folded into various tubes and tentacles, is at once a muscular, an osseous, and a cutaneous system; a vascular, digestive, and generative system; with the additional functions of sensation, to perform in such degrees as are required for self-protection and instinctual guidance.

There is a delicate nervous system in the highest types of radiata; calcareous deposits form a kind of skeleton in the ectoderm of the echinodermata; muscular fibres

have been described, as more or less distinct from the cutaneous tissues; glandular organs have also been described; but all are of a very low degree of organisation. It is not marked difference of structure that we recognise in the organs and connective tissues of the radiate organism, but positive differences of function in slightly differentiated systems; and these may be classed as organs of nutrition (digestive and circulatory); reproduction; cutaneous, muscular, and nervous systems; with prehensile apparatus, and suckers as organs of sense. Glandular excretions are manifest; and lubricative secretions are required for motion in all animals. Areolar connective tissue is essential, and therefore we have here, as in the higher organisms, one main class of tissues, and three connective classes. Simple as the highest radiate organism may be, we have a complete scale of functions, and slightly differentiated systems, almost as numerous in this realm as in the higher vertebrata; and we may expect to find as many slightly differentiated classes and alliances, orders and families, in one as in the other. This may be expected in all realms, since diversity of form and function is the main principle of divarication, while complexity of structure is only secondary.

If the organs are but slightly differentiated in the individual body of the highest radiata, we may observe that the predominant forms of differentiation are but few in the highest class of the same realm. Three or four types are markedly distinct, such as the spherical, the asteroïdal, and the tubular. De Blainville places holothuria at the head of the list of three sections, *i. e.*, holothurida, echinida, and stellerida; he then forms six orders of holothurida, and three of stellerida. Lamarck makes only two orders of the tubular radiata, *i.e.*, *holothuria* and *fistularia*. Brandt, also, makes two primary divisions, under the names of *apodes* and *pediculata*: the

first he subdivides into *pneumophora* and *apneumona;* the second into *dendropneumona* (arborescent respiratory organs) and *apneumona* (no visible organs of respiration).

In the present state of knowledge of this realm, it is hardly possible to form a perfect table of the natural alliances and orders of each class. The arrangement of Professor Reay Greene differs from that of Milne-Edwards. The former establishes four orders of actinozoa, *i.e., zoantharia, alcyonaria, rugosa,* and *ctenophora;* seven orders of hydrozoa, namely *hydridæ, corynidæ, sertularidæ, calycophoridæ, physophoridæ, medusidæ,* and *lucernaridæ.* In the class of protozoa his primary divisions are, *rhizopoda, polycistina, spongidæ, thalassicollidæ, gregarinidæ,* and *infusoria.* The main question for our consideration is that of natural distinctions in accordance with a general organic law.

The respiratory apparatus in the dendropneumonic holothuria is superior to that of *echinida* and *stellerida;* and other points of structure point them out as a superior class.

Three leading types have been recognised in this class by some zoologists,—*holothuria, synapta,* and *sipuncula;* but the latter is now considered as an annelid. There are still, however, two sub-classes usually termed *pediculata* and *apodes;* and although few families of the latter sub-class are yet known, time may bring many others to our knowledge. Hundreds of species of radiata are now described which were unknown fifty years ago; and not one half of all the living and fossil types of this realm were known before the present century. The first divisions of mammalia into ungulata and unguiculata were very insufficient for a natural arrangement of orders and alliances in the highest class of vertebrata, and these first distinctions of pediculata and apodes may be insufficient

for a natural arrangement of the holothuria. In other realms the highest class is generally better known than the lower classes; but in this the lower classes are more familiar to zoologists than the highest.

The echinodermal class, properly so called, without the holothuria, has been subdivided into four sub-classes or alliances, namely, echinida, asteroïdea, ophiurida, and crinoïdea; the latter being mostly fossil and more anomalous in form and structure than the others. In the vertebrate ovipara we have four sub-classes of birds and four of reptiles; and the latter differ very much from one another, as chelonia, sauria, ophidia, and batrachia. The four sub-classes of echinodermata are also very different in form; but the transitions from one to another are very gradual. As in the extinct types of reptilia, some strange forms claim affinity with one sub-class of living types, and some with another; so in the fossil types of crinoïdea some claim affinity with one of the living orders of echinoderms, and some with another. The cystoïdea seem nearer to echinida than to asterias or ophiurida, while other fossil types are nearer to the latter than the former; though none of these crinoïdea, properly so called, belong to any modern type, except that of the "pentacrinus" and the "caput Medusæ."

In the class *celenterata*, Professor Reay Greene establishes two sub-classes, namely *hydrozoa* and *actinozoa*. Cuvier makes also two divisions of this class, *acalephæ* and *polypi*. In both cases the divisions are called classes; but the limits of each, and their respective subdivisions, differ widely from each other. Cuvier places the *entozoa* as a class of radiata, which have since been recognised as annelids; and many of his *infusoria* and *polypi* have also been removed to other groups. The natural divisions of celenterata are, therefore, still unsettled; but those of *acalephæ* and *polypi* (*carnosi, gelatinosi, polypiferæ*), as named by Cuvier, are probably the simplest.

The secondary classes are better defined now than formerly; while the chief class is still imperfectly described. We shall, therefore, be obliged to leave some unknown types of vermiform radiata as absent families in our parallel of natural organic unity. We have no doubt, however, of the existence of these types, and the superiority of holothuria, as a class, compared with that of the echinodermata. It is only in some points of structure that mammalia are superior to birds, and these again to reptiles; and so it is with holothuria compared with radiate echinoderms. As in the lowest realm of vegetable organism, tree-ferns have the semblance of a higher form, so the holothurida have some resemblance to annelids belonging to a higher realm. Professor Huxley has even ventured to class echinoderms as an inferior type of annulosa, under the name of annuloïda.

There are two sub-classes of vermiform radiata, the one being much less unlike annelids than the other. Much uncertainty is yet involved in the question of admitting or rejecting *sipunculus* and *thalassema;* some zoologists claiming them as annelids, while others deem them merely apodous holothuria. We do not pretend to an opinion on these points, nor shall we attempt to meddle with distinctions recently made by working naturalists; but as these differ, we shall take Brandt and De Blainville as the best authorities for us at present; and the more readily as the latter adopts, under new names, all the leading distinctions of the former, with one or two exceptions of no great importance. De Blainville's "*vermiformes*" are Brandt's "*apodes*"; his "*veretilliformes*" are Brandt's "*sporadipodes*"; and other divisions run exactly parallel, under the names of *fusiformes, heteropodes, ascidiformes, hypopodes, cucumiformes, peripodes.* The *sipunculiformis* of De Blainville has no corresponding name in Brandt, unless it be understood as one of his *apodes.* The latter makes

a special division of his *homoïopodes* for the genus *oncinolabes*, in which the ambulacral suckers are very small, and in five bands, somewhat as in *cucumiformes;* and these are also separated from the latter by De Blainville, who places them along with *synapta* and *chirodota* in his vermiformes.

In forming our synopsis of the realmic unity, and placing holothuria as the highest class, we have now to consider which are the highest types in this class, as man is in the class mammalia. In the latter the bimana stand first in rank, the quadrumana second, the digitigrada third, the plantigrada fourth, rodentia fifth, pachydermata sixth, ruminants seventh, and horses last. Not that the gradation is one of a regular progression in general structure ; but, in the digital extremities, man is at the top of the scale, and the horse at the bottom. In dealing with the holothuria, we place the apodous vermiform types above the pedaneous, as being nearer to the annelids, and therefore nearer to the forms peculiar to a higher realm. This may be right or wrong, but it will serve our purpose until more is known of this great class, to warrant a complete arrangement of all its families and orders. There is, however, a complete scale of systems in the individual organism of holothuria, and we may, therefore, expect to find, eventually, a corresponding order of completeness in the orders and series of the whole realm.

Although the highest organisms of radiata are very simple in structure, we may recognise in the external frame a calcareous deposit, more or less analogous to the outer framework of a tortoise; with nerves, muscles, and cutaneous tissue analogous to those of higher animals. Digestive, vascular, and generative systems are more or less distinct ; glandular, lubricative, and areolar connective tissues are also found in them. We have, in a rudi-

mentary degree, all the systems of a higher organism present in the radiata, and a parallel may be formed between the collective and the individual unities of this realm. It will be very incomplete; nor is it probable that we can place any family or series in its proper rank; but the following synopsis will serve a tentative purpose, until more is known and understood of all the leading types of the chief class.

We give both Brandt's and De Blainville's names and definitions, as they are almost identical in natural delineations; so that there is no obscurity in giving two names for the very same types and families.

"*Holothuria Vermiformis.*—Body elongate, soft, vermiforme; no feet, or suckers; tentacula, pinnate in *synapta*, and pinnatifide in *chirodota.*

"*Holothuria Ascidiformis.*—Body short, coriaceous, convex above, flattened below, with the orifices superior rather than terminal. Skin scaly in *hol. squammata;* soft but rugose in *psolus.*

"*Holuthuria Veretilliformis.*—Body considerably elongated, rather soft, cylindrical, covered throughout with suckers, of which the inferior are the longest.

"*Holothuria Fusiformis.*—Body more or less elongated; the inferior suctorial feet longer than the superior, and disposed in a determinate number of longitudinal rows.

"*Holothuria Cucumiformis.*—Body but little elongated, pentagonal, with the tentacular feet forming five ambulacra, one along each angle.

"*Holothuria Sipunculiformis.*—Body more or less suddenly narrowed behind; the pentagonal figure indistinct, without ambulacra."

Chirodota lumbricoïdes seems to be the highest known form of holothuria, and therefore we give it the first rank. The *chirodota verrucosa* follow closely, and

then *synapta;* the other types appear to claim the places given in the following synopsis.

We have very little doubt that several new families of holothuria and synapta will be discovered by naturalists, when the ocean has been well explored in every depth and latitude. It may be found, eventually, that the lowest types of the so-called "annelata," such as sipunculus, echiurus, etc., which Cuvier classed with holothuria, may really belong to the vermiform radiata, as no rings are manifest in their "annuloid" bodies; and the most eminent working naturalists are undecided on this question. They may not be individually undecided, as each one may feel satisfied that he is right; but then they differ very widely from each other on this point. Mr. Huxley agrees with those who remove the gephyria from the radiata, but, then, he also removes the whole class of the echinodermata from Cuvier's radiata, dividing the other types of this realm into two subkingdoms, as "*cœlenterata* and *protozoa*." These two divisions are natural and well defined; but do not claim the rank of subkingdoms, nor do they differ greatly from the type of radiata in the starfish and echinus. By making five subkingdoms in lieu of four, Huxley has not improved Cuvier's divisions; and, by placing echinoderms with annelids, he has made an incongruous agglomeration.

On the same grounds of nicety in names and definitions, it might be said that the amphioxus is not a truly vertebrate animal; and that the lowest forms of all the realms were separate subkingdoms, having no very marked affinity of structure with the highest types classed under the same general names.

There is evidently something wanted to solve the vexed question of the natural delimitations between annelata and the vermiform types of radiata. We do not pretend to settle this question, but the mode in which Huxley has unsettled it is not definitive.

Many species of holothuria have, no doubt, been discovered by naturalists since Brandt and De Blainville arranged them into orders, families, and tribes, but it is very difficult to find the books in which new species are described; and, although many hundreds of specimens exist in the collection of the British Museum, they are hidden away in cellars, without orderly arrangement, so that no one can profit by the inspection or the dissection of these innumerable treasures. It is high time that some competent person should undertake a systematic arrangement of all the known families and tribes of holothuria, and publish accurate drawings and descriptions of every distinct species and variety. The drawings that are given in most compilations are very inaccurate; and very few of these are to be found in any book or publication. We have spent many months in searching for a complete collection of specimens or drawings, without a satisfactory result. The following synopsis must be regarded, therefore, as a very meagre outline of what might be given, with a more complete knowledge of what is already known: not to mention numerous tribes and species yet unknown.

COLLECTIVE RADIATE ORGANISM.

Z.	Supernal forces, etc.	H. *Embryonic supplies.* U. Climatic conditions. ∩. Food resources. O. Physiorganic forces.
Y.	Ingesta, etc.	H. *Impregnata.* U. Investa. ∩. Recent ingesta. O. Blood.
X.	Exuviæ, etc.	H. *Parturitional out-births.* U. Glandular excretions. ∩. Lubricative secretions. O. Necrological exuviæ.
W.	Connective Classes.	H. *Extinct crinoïdea, etc.* U. Class echinodermata. ∩. Class cœlenterata. O. Class protozoa.

VII.	VERMIFORM Apodes.	H.		
		U.		
		O.	Chirodota (verrucosa) ?	
		Ω.		
·7.	Vermiform Apodes.	H.		
		U.		
		O.	Oncinolabes (?)	
		Ω.		
VI.	VERMIFORM Apodes.	H.		
		U.		
		O.	Synapta (mammillosa) ?	
		Ω.		
·6.	Vermiform Apodes.	H.		
		U.		
		O.	Synapta (reciprocans) ?	
		Ω.		
V.	CUCUMIFORM Peripodes.	H.		
		U.	Liosoma (?)	
		O.	Chladodactylus.	
		Ω.		
·5.	Cucumiform Peripodes.	H.		
		U.		
		O.	Dactylota.	
		Ω.		
IV.	VERMIFORM Apodes.	H.		
		U.		
		Ω.		
		O.	Chirodota (lumbricoïdes) ?	
III.	FUSIFORM Heteropodes.	H.	(*Suckers in three rows*).	
		U.		
		Ω.		
		O.	Stichopus.	
·2.	Fusiform Heteropodes.	H.	(*Suckers in five rows*).	
		U.		
		Ω.		
		O.	Diploperideris	
II.	ASCIDIFORM Hypopodes.	H.		
		U.		
		Ω.	Cuvierii	
		O.	Psolus.	
·1.	Veretelliform Sporadipodes.	H.		1. Thelenota.
		U.		2. Camerasoma.
		Ω.		3. Platysoma.
		O.	Holothuria.	4. Microthele.
I.	VERETILLIFORM Sporadipodes.	H.		
		U.	Bohadschia.	
		Ω.	Trepang.	
		O.	Mulleria.	

REALMIC UNITY OF RADIATA.

Class Echinodermata.—With holothuria as the main class, we have echinodermata, cœlenterata, and protozoa as secondary classes. Agassiz (1836) forms two main divisions of echinoderms (besides the holothuria), "*stellerides* and *echinides*," each of which he subdivides into three minor groups: "*asteries, ophiures, crinoïdes;*" "*spatangus, clypeastres, cidarites.*" MM. Gervais and Van Beneden, more than twenty years later (1859), divide the "*echinides*" into four families, and the "*stellerides*" into two orders, *i.e.*, "*asterias* and *encrines.*" These contain six minor groups: "*asteriadæ, euryalidæ, ophiuridæ,* and *comatulidæ;*" "*encrinidæ* and *cystocrinidæ.*" From this it appears that Agassiz forms three families of echinida and three of stellarida; while Gervais and Van Beneden admit four families of echinida and six of stellarida.

In the most complete type of individual radiate organism, there are glandular tissues conjoined with the vascular, the digestive, the reproductive, and the cutaneous systems. These four alliances would give us seven orders; and not improbably seven groups of echinodermata, in addition to the extinct types of crinoidea, might be formed more accurately than either the six of Agassiz, or the ten of Van Beneden. We have not time, however, to investigate minute details, in order to test the question by comparative anatomy; but the following alliances seem quite natural:

1. Echinal alliance.
2. Asterial alliance.
3. Ophiural alliance.
4. Encrinal alliance.

Class Cœlenterata.—This class is now subdivided

by naturalists into two sub-classes, namely, "*hydroza* and *actinozoa*." The first is divided into seven orders, the second into four, thus :

HYDROZOA.	1. Hydridæ. 2. Corynidæ. 3. Sertularidæ. 4. Calycophoridæ. 5. Physophoridæ. 6. Medusidæ. 7. Lucernaridæ.	ACTINOZOA.	1. Zoantharia. 2. Alcyonaria. 3. Rugosa. 4. Ctenophora.

Milne-Edwards makes but two divisions of "acalephes" or hydrozoa, and four of "polypi" or actinozoa. The minor groupings of these two subclasses are evidently unimportant.

CLASS PROTOZOA.—Here again Milne-Edwards forms two subclasses of his "*sarcodaires*," *i.e.*, "*infusoires* and *spongiaires*," with three minor groups in the one and two in the other. Those who follow Mr. Huxley, divide the "sarcodaires" or protozoa into six minor groups, under the names of "*rhizopoda, polycistina, spongidæ, thalassicollidæ, gregarinidæ*, and *infusoria* ;" or otherwise, "infusoria, *noctilucidæ* ; spongiadæ, foraminifera ; gregarinidæ, *thalassicollidæ* ;" or otherwise, again, in four groups only, *i.e.*, "infusoria, spongida, rhizopoda, gregarinida."

These unsettled modes of grouping protozoïc types, show that nothing very marked divides one order from another, and that secondary grouping is of little or no importance in such cases.

PHYSIOLOGICAL CHARACTERISTICS OF RADIATA.

IN this, as in the other inosculatory realms, the physiological characteristics are very curious and interesting. Animal life and vegetable life approach each other very

closely in their modes of action. The former name of radiata was, in fact, composed of the two words *zoon* and *phytes:* zoophytes, or animal plants. There is no union, however, of animal and vegetable tissues in the organism of radiate animals; nor are the peculiarities of reproductive modes of action and collective aggregation restricted to the lowest classes of radiata, as similar peculiarities are found in the lower classes of mollusca and annulosa. This may be aptly illustrated by a quotation from the *Rambles of a Naturalist,* by A. de Quatrefages (vol. ii, p. 233, English translation).

"Every living being is produced from an egg, or, to adopt the axiom of Harvey, *omne vivum ex ovo.* If by this word we understand something that is always identical with, and more or less similar to, the egg of the bird, the inaccuracy of the aphorism would be evident. A plant is multiplied by seeds, buds, bulbils, cuttings, etc., and animals present to us precisely analogous facts. If, for instance, we take one of those fresh-water hydras, so common in our ponds, and cut it in pieces, we shall find, in the course of a few days, that each fragment has become a complete individual. (Just as the cuttings of a tree become complete little trees.) This is a reproduction by cuttings. If we observe the same hydra in the vessel into which we have thrown for its nourishment the larvæ of insects or of naïdes, we shall perceive that, at one time, it will lay eggs, covered by a solid shell, that is to say, it will produce true animal seeds; while, at another time it will give off buds, which grow, become more and more organised, and at length appear in the form of a young hydra, furnished with all its organs. At first adherent to the parent, and in direct communication with it, this newly formed being in all respects resembles a parasite, and is like a tender branch, which derives all its nourishment from the trunk. After a few days, when

the mouth is formed and the arms have grown longer, the young hydra begins to seek for prey on its own account, and thus contributes towards the general maintenance, in the same manner as the developed leaves of the young branch extract their portion of nutrient elements from the atmosphere. The branch, indeed, never leaves the stem from which it sprang; while the hydra, on the contrary, after having attained sufficient size, separates itself from the body which had previously nourished it, and begins to lead an entirely independent life. In addition to the seed, properly so called, which reproduces the plant, and the bud which becomes developed into a branch, there exists in certain plants a kind of intermediate structure, which is called a *bulbil.* It resembles an ordinary bud in its composition, but, like the seed, it must be detached from the plant and developed apart from it, before it can give origin to a new individual. Animals, in the same manner, exhibit reproductive bodies, which are at once allied to buds by their structure, and to ova by their functions. Let us examine some of these synhydras, a kind of polype, which I found on the shores of the Channel. You will often observe on some old and worn shell a somewhat thin stratum of a fleshy substance, bristling with small protuberances, and held together by a network of horny matter. This is the polypary, or common body, to which the entire colony is attached. The animals, which are very similar to our fresh-water hydras, have an elongated body, terminating in a mouth, surrounded by six or eight moveable tentacles, which fulfil the functions of arms and hands. Narrow channels, forming a network, pass from one individual to another, and maintain a communication between all the digestive cavities, so that the nourishment taken by each polype tends to the direct support of the entire community. This animal is multiplied in three different ways.

"From the fleshy polypary, of which we have spoken, are given off *buds*, which increase and become organised in the same manner as those of the hydra, but without ever leaving the place of their birth. They comport themselves, therefore, precisely in the same manner as the buds of a tree.

"In the thick substance of this same polypary are developed *eggs*, properly so called, and these eggs, when they are ejected from the body within which they took their origin, comport themselves in the same manner as the seed which is developed and propagates the species after separation from the parent plant.

"Finally, a certain number of individuals are destined to generate deciduous buds or true *bulbils*, the propagation of their species being the only function which they have to fulfil; they have neither arms nor mouths, and are nourished by their neighbours. These ovoïd buds are detached from the parent stock at certain epochs, and are carried away by currents. Many no doubt perish, but those which encounter a favourable locality become fixed, and, in a few days, after undergoing elongation, give birth to a polype, which is at first isolated, but afterwards becomes, in its turn, the original stock of a new colony.

"We see, therefore, that there is not so great a difference between the seed and the vegetable bud, or between the egg and the animal bud, as we might at first have been led to suppose. In these two kingdoms of nature, the bulbil occupies an intermediate position. We may, however, employ a more general term to designate these different reproductive bodies, and define them in a more precise manner. The bud is a *germ* which requires for its development that it should adhere to a parent, which does not, in reality, deserve the name either of male or of female; the bulbil is a *germ* which is detached from the parent, and is developed without fecundation; whilst the

egg is a *germ* which for its development requires the concurrence of the two sexes, and is also detached from the parent.

"It is well known that the viviparous as well as the oviparous animals proceed from an egg; the only difference between these two modes of development is, that, in the former case, the egg is detached from the ovary, and undergoes development within the body of the mother.

"Finally, then, every living being proceeds from a pre-existing germ, and such is, in fact, the true translation which we ought to give of the Latin aphorism to which we have referred."

From this brief outline of the different modes of reproduction in both animals and plants, we may see that different modes of attaining one end exist in nature; and that the lowest realm of animal life approaches very nearly to certain forms and modes of action, which are more conspicuously manifested in vegetable life. We cannot perceive conscious instinct in the highest forms of vegetable organism, as we do in the lowest forms of animal individuality, but we see many physiological modes of action common to both kingdoms. Certain very marked signs of physical attraction and repulsion, expansion and contraction, in the living tissues of some plants, are more or less analogous to the physical sensations, expansions, and contractions in the living tissues of all animals. There is a bond of union, then, between the living organisms of animals and plants; but how the physiorganic forces of attraction and repulsion merge into the physioinstinctual forces of sensation, and these again into the emotional forces of attraction and repulsion, we cannot possibly determine; and we are still more blind, if possible, with regard to the connection of the physiomental forces of human understanding and intelligence, with all the other kinds of forces.

We know *where* all these limits are distinctly marked in all the realms, but nothing of the *how* and *why* of such connections and decided separations. Let us, then, observe the next degree of organic degradation which is exhibited in the vegetable kingdom, the organic forms of life in the structural and physiological phenomena of the phanerogamic realm.

But is there nothing in the human body that might throw some light on these perplexed questions? What is the nature of the physiorganic force which forms a hair on the body of an animal, without the conscious working of the instinct in that operation? Is there a class of physiorganic forces in the globe which gives vitality to vegetable germs, as the vital forces of the animal give organic life to the piliferous glandulæ and their secreted hairs? The parallel is not on the same plane of physiorganic phenomena, since the hairs are not seeding organisms; but John Goodsir's physiological investigations lead us to infer that epithelial cells are the secreting organs on the surface of all glandular tissues, and that these cells are reproductive bodies, new layers of them being produced by the older ones, as these decay and are egested from the body. Here, then, are reproductive cells developed in the body, without the conscious efforts of the mind, and yet proceeding from that unity of supersensuous forces of which the conscious intellect is but a part, controlling the external relations of the organism, while unknown forces regulate the inmost operations of vitality in the whole being. We need not dwell, however, on these questions here, as we shall have to deal with them elsewhere, as far as science and philosophy can lead us in their present state.

OUTLINES OF PHANEROGAMIC UNITY.

As the individual organism of an animal is a type of natural organic unity, so is the vegetable organism in its degree; and we may look to one as well as to the other for a pattern of taxionomic method in each of their respective realms. The highest type of vegetable is an exogenous plant or tree, in which we easily distinguish *root, stem,* and *branches; rootlets, leaves,* and *flowers.* In a methodical analysis we may first distinguish, in the stem, the bark from the wood, and both from the pith and medullary rays. Some of these are also more or less developed in the roots, but with a marked difference of character and function. The root, in fact, is the digestive system of the plant, and only differs relatively from that of animals in being *everted* instead of being *inverted* in position. In the higher animals the lungs and the alimentary canal are inverted continuations of the external frame, and more especially of the external skin. In some of the lower animals the branchial apparatus is everted, or external; and in the protozoa there is no distinction between endoderm and ectoderm, both being equally external. The same occurs in plants, the roots of which, instead of being inverted alimentary tubes, are external continuations of the stem, but under ground, and hidden from the light. The bark of roots, however, differs from that of the stem, perhaps as much as mucous membrane differs from the skin; and peculiar organs of secretion in the root differ from those of the stem, in certain plants, as much as digestive glands differ from vascular and generative glands in animals.

Besides these permanent systems of vegetable structure there are different kinds of ducts and spiral vessels permeating all the tissues of the stem and roots as well as

of the leaves and flowers, the latter being more or less temporary and caducal organs. These are none the less essential parts on account of being easily withered and reproduced. In the lowest types of animal life we find a somewhat analogous fact in the occasional loss and reproduction of important organs, such as the claws of lobsters, and even, it has been affirmed, of the internal viscera of holothuria.

As in the animal so in the vegetable organism, we may distinguish the "relational" from the "organic" mechanism of the individual type. In both there are vascular, digestive, and generative systems. In each there are systems corresponding, in some measure, to the skin, the muscles, the bones, and the nerves. The bark of a tree is analogous to skin, and wood to bones; pith and the medullary rays being the centre of life and growth in plants, are more or less analogous to the nervous system of an animal. Analogy, however, is not our only guide in analysing plants; and whether or not there be a functional correspondency of any kind between the medullary system of an animal and that of a vegetable in the phenomena of physical vitality, there certainly is a central medullary system as well as a medial woody system, and an external tegumentary system in all flowering plants of the highest types; and, as in animals we distinguish muscles from bones, although they are bound together in the closest manner, so we may distinguish *heartwood* from *alburnum* in the stems of trees. We may therefore institute a parallel of systems in the vegetable organism analogous to that which we have found in animals, as far as physiorganic structure and function are concerned, irrespective of instinctual and higher faculties of life. And this is one great proof that physiorganic forces and material structure are not always necessarily allied with instinctual and moral faculties and forces in the organic unities of nature.

Besides the bark, alburnum, heartwood, and medullary rays, of the stem of a tree, we have roots and rootlets, vessels and leaves, flowers and fruits; and in addition to these main systems we have general connective tissues, glandular and cellular, starch secreting tissues, gum and oil secreting tissues, and some which are merely connective in structure and in function: a complex unity, in fact, of vegetable life exactly parallel with that of animal organic individuality. The one is certainly more simple than the other in many points of view, although apparently more complex in another; for a tree may be compared with a community of individuals rather than a single one, as it has a double mode of reproduction in what are called *leaf-buds* and *flower-buds;* the one increasing the branches, or members of the tree itself, as a collective individual; and the other reproducing seeds to multiply the species by colonising neighbouring localities or distant lands. This complex organism of an exogenous plant is not, however, more peculiar than that of certain complex animals of the lowest types, such as the stephanomiæ, of which M. De Quatrefages gives the following description:

"Systematic naturalists have arranged next to the Medusæ and beroïdæ the *stephanomiæ*, which, with other hydrostatic acalephæ, rank amongst the most extraordinary of marine animals. Imagine an axis of flexible crystal, sometimes more than a yard in length, around which are attached, by long and equally transparent peduncles, hundreds of small bodies either elongated in form or flattened, and looking like the buds of a flower; and then intersperse in this garland beads of the most vivid red blended among an infinite number of variously sized filaments. Add motion and life to all these parts, bearing in mind that each one is an organ possessed of special functions,—the one being destined to seize food, another to digest it, a third to assure the propagation of the

species, a fourth to carry on the respiration, and a fifth perhaps to serve as eyes,—and, after the consideration of all these things, you will still have only a feeble idea of the wonderful nature of this organisation. It constitutes a kind of colony, not of distinct individuals, as in the case of polypes, but of freely floating organs. It would be much the same as if, in the case of man, the hand, the mouth, stomach, intestine, and lungs, indefinitely multiplied, were attached to as many threads issuing from an isolated vertebral column. All these organs intermix and become incessantly blended together round the slender axis which connects them. The organs of locomotion are alone grouped into one mass, apart from the rest, at the anterior extremity. They consist of a considerable number of small bells soldered together to the central stem, with the opening directed backwards. These little bells are incessantly dilating and contracting. By these alternate movements the water contained within their cavities is forcibly driven out, and the little bells being pushed forward by the resistance of the liquid, draw after them the other parts of the body. This peculiar structure, which has no analogue in the animal kingdom, places the stephanomiæ apart from all other animals: hence it is only by a careful study of their embryology that we can hope, by the discovery of their real affinities with other types, to ascertain their correct place in our zoological system......Since the hydrostatic acalephæ, or syphonophora, have been better known, some naturalists have proposed a new point of view from which to consider the structure of these singular beings. According to them each of the syphonophora is a colony of distinct individuals, some of which are charged with the functions of locomotion, others with those of nutrition, etc. We must admit that recent facts have come to light which seem to give it a certain character of probability."

This description shews that the respiratory, digestive, and reproductive organs are everted and external appendages in the lowest type of animals as well as in the highest vegetable types of complex organism.

Beyond observing that a tree is a community of individual plants with a digestive system common to them all, and leaves or lungs, flowers and fruits, as respiratory and generative apparatuses numerously multiplied, everted, or external and deciduous, just as in the case of certain polypes or animal communities, we need not enter into the minute anatomy and physiology of plants, as these are questions ably dealt with in elementary works. Our business is with general principles; and the reader will refer to Lindley's *Elements of Botany* and his *Vegetable Kingdom*, or some other works of recognised authority, for such details as are omitted here.

It is easily seen that flowers and fruit belong to the reproductive system of a plant; that air vessels, sap vessels, and leaves belong to the vascular system; that roots and rootlets, which abstract nourishment for the plant from the matter and the water of the soil, belong to the digestive system; and that the general bark alburnum, heartwood, and medullary system of the stem, differ from these as the skin, the muscles, the bones, and the nerves of an animal differ from the generative, the vascular, and the digestive systems; this is all that is required for a parallel between an individual flowering tree and the collective realm of phanerogamia, as complex organisms of the same character.

SYNTHETIC ARRANGEMENT.—And now we have to deal with the whole realmic unity, as we have dealt with that of an individual tree. The task is not, however, quite as simple: for systematic botany is not as far advanced as vegetable physiology and anatomy.

Flowering plants have been definitely separated from

non-flowering plants, and classes have been well distinguished from each other in each realm ; but much confusion still exists in the various methods of distinguishing subclasses and alliances of both the main and secondary classes of phanerogamia. Botanists are much divided in their views of fit divaricating characteristics in the organs and functions of plants. Some put forth one set of features, and some another. In dividing exogens from endogens, they have uniformity of character in the seed, the leaves, and the wood to guide them : the smallest, the largest, and the middle terms of organisation being almost equally certain as indications of the structure of the individual, and the natural division to which it belongs. A *monocotyledonous* seed, *endogenous* wood, and *parallel veins* in the leaf accompany each other almost invariably, and any one of these, with some exceptions, implies the other. *Dicotyledonous* seed, *exogenous* wood, and *ramified veins* in the leaf, are also, with few exceptions, equally correlative characteristics in their class. The numbers, three and five, as elementary divisions of the flowers, are very common also, though not certain features of distinction, between endogens and exogens. Nothing of the same importance has been yet discerned as unerring features of distinction between one alliance and another in the highest class of plants. Some look for features in the fruit as most important ; others in the seed. Formerly the flowers were considered most indicative of high distinctions, and are so still by Ad. de Jussieu ; but Lindley and Brogniard, not to mention some of the German botanists, refuse the first consideration to the flower, and trust to features of the seed more willingly. The form of the corolla is deemed subordinate by Lindley, in comparison with the position of the stamens, while the latter was deemed secondary by De Jussieu. These are puzzling dissidences for a general student, who finds con-

fusion among his teachers. They all confess that something is still wanted to clear away the difficulty. Adrian de Jussieu observes that "all botanists of experience admit the primary divisions of class according to the nature of the seed, as first established by his uncle A. L. de Jussieu, and that it is only on the question of secondary degrees of distinction that dissidence arises." It is not his business, he adds, "to discuss these questions of dissidence, so long as they exist without any present chance of settlement; but to wait patiently until they subside naturally, either by the discovery of facts unknown at present, or by the happy efforts of genius in discovering some new basis of arrangement, which shall win assent from all by natural conviction." Meanwhile he adopts the plan of his uncle, with a different order of progression; and observes that "De Candole, in changing the names, has not modified the plan, insomuch as the *thalamiflores* of the one exactly correspond to the *hypopetales* of the other; the *calyciflores* to the *peripetales;* and the *monochlamydées* of De Candole, corresponding to the *apetalés* of De Jussieu, the former has followed the same rule in distinguishing the forms of the corolla and the modes of insertion, differing only in the arrangement of his two last great classes, each of which embraces several of those established by De Jussieu."

That all the plans are more or less defective is quite clear, since none of them can supersede the others; but, as Lindley seems to be the best authority, we may use his works as text-books, with occasional reference to others when required. In the synthetic arrangement of plants we differ from botanists, as in that of animals we differ from zoologists, to some extent, and for the very same reasons. We follow the law of order established in the human body and in the musical scale, known by the technical name of "harmonic fractions." Others follow

the various indications of diversity of structure, on the *ad libitum* principle of "vulgar fractions," which may be multiplied in numerous ways to a great extent, as illustrated by the different so-called "natural arrangements" of systematic botanists and zoologists.

Lindley makes five classes of flowering plants: *rhizogens, endogens, dictyogens, gymnogens*, and *exogens:* the *first* and *fourth* are classed as exogens by other naturalists; the *second* and *third* as endogens; they are not, therefore, proper class distinctions, but they are no doubt very marked divisions, worthy of attention. In the exogenous class he makes four subclasses: *diclinous exogens, hypogynous exogens, perigynous exogens*, and *epigynous exogens*, in each of which he establishes numerous alliances. The usual distinctions of *polypetalous, monopetalous*, and *apetalous* subclasses are thus neglected, and the secondary characters of De Jussieu are made primary. This may be legitimate in a certain degree, but it only corresponds to the primary distinctions of zoologists in classing mammalia as *ungulata, unguiculata*, and *cetacea*, or as *placentals* and *implacentals*. Ruminants and pachydermata, including horses, are no doubt ungulate; while bimana, quadrumana, carnaria, marsupiata, rodenta, and edentata, are unguiculate; but that is really of small importance in a regular plan of subdivision: the unguiculate rodents being much more nearly allied to the ungulate pachydermata than to carnivorous unguiculata.

In natural method, the primary subdivisions of a main class, in any realm, are those which correspond to the relational and organic mechanisms of the individual body; the next are those of the seven systems or twelve orders, each of which are further subdivided in regular series of organs. The vegetable organism is formed on the same general plan; and, as the collective realm of vertebrata answers to the law of individual organic unity, we

may expect the same of vegetable individual and collective parallels. We shall therefore have a better chance in looking for seven primary distinctions than in accepting four subclasses, the more so as botanists do not accept them universally.

In the "diclinous" subclass of exogens, including rhizogens and gymnogens, as Ad. de Jussieu has given it, we observe a certain parallel with Cuvier's division of ungulata, and divide it into several alliances, corresponding with those of ungulata in our synopsis of mammalia. These alliances are subdivided into orders in both cases, and almost with the same regularity. We shall not interfere much with such divisions as are generally recognised by competent authorities, but merely alter names and ranks when necessary: leaving certain questions undecided, until further knowledge has been acquired by naturalists themselves. In differing from any one of them, we shall agree with others, without presuming to make any alteration of a fundamental nature, although we may suggest where changes should be made, and in what direction.

The highest type of vegetable we place in the highest rank of an organic scale; and this, according to Ad. de Jussieu, belongs to the composite order of phanerogamia. The nearest type to this may claim the second rank; and, as Linnæus classes monkeys with man, in his order of "primates," so Lindley classes *campanula* in the same alliance with *asteracea*, whence we may presume it is entitled to as high a rank, or nearly so. The monopetalous types rank higher generally than the polypetalous and the diclinous, although this is not a rule; just as in mammalia, unguiculata hold a higher rank than ungulata, although not invariably. Lindley states that monopetalous and polypetalous distinctions sometimes blend in higher characteristics. None of these distinctions, there-

fore, separate one group from another in certain orders and alliances. Diclinous species sometimes mingle with apetalous and polypetalous genera, and all may sometimes find a very close affinity with monopetalous tribes. In numerous alliances established by Lindley, monopetalous, apetalous, and polypetalous groups are brought together; and two of his classes (rhizogens and gymnogens) are separated from the diclinous subdivision of De Jussieu. We want some further aid than that which is afforded us, in forming natural divisions in this realm; and, where we cannot find it, we must rely on our own perception of analogy.

In the class mammalia we find numerous types which are more or less anomalous, but these are easily referred to their respective orders and alliances. The bats to quadrumana, cetaceans to pachydermata, and marsupiata to the plantigrade alliance. Our knowledge being more restricted in botany than in zoology, makes it easier to find the affinities of anomalous types in one kingdom than in the other; and botanists must rectify our tentative arrangement, when they become acquainted with the principles of natural organic method. The following synopsis is the nearest approximation we can give at present of the primary divisions of the exogenous class of flowering plants; those of endogens are not so difficult, nor are they of so much importance.

Here again, however, Lindley differs from De Jussieu: one making three classes, and the other two. The secondary divisions are more or less alike in both; but De Jussieu's classes simplify the study more than Lindley's. In our arrangement of endogens, we follow De Jussieu, and recognise three classes named by him, *aquatic* endogens, *aperianthous* endogens and *perianthous* endogens. The distinctions may not be as rigorous as perfect science needs, but names and definitions are not more perfect in

other systems, with the further disadvantage of being less simple. Lindley's "vegetable kingdom" will be just as convenient for reference in one plan as in the other, the families and orders being much the same in both. For the sake of comparison, we give the two together

CLASS I.—AQUATIC ENDOGENS. (SEEDS WITHOUT ALBUMEN.)

ALLIANCES.	*Orders.*
I. HYDRALES.	1. Hydrocharidaceæ; fresh water plants. 2. Naiadaceæ; fresh water plants. 3. Zosteraceæ; sea-wracks.
II. ALISMALES.	5. Butomaceæ. 6. Alismaceæ. 7. Juncaginaceæ.
III. ANOMALES (?)	1. Lemnaceæ; duck-weeds. 2. Potomogeton; pond-weeds.

The two last groups are placed in this class by Ad. de Jussieu, and are acknowledged to be of an ambiguous kind by Lindley, who places *duck-weeds* in his aral alliance, and *pond-weeds* among juncaginaceæ. It is perhaps of no importance, in a general point of view, where ambiguous types are placed; but it is important in natural method to place anomalous vegetable species with their true affinities. As bats belong to monkeys, and cetacea to pachyderms, so ambiguous families of plants belong to certain orders, and should be classed with them. We cannot decide between Lindley and De Jussieu in this case; but as the one includes pond-weeds in this class, and the other includes duck-weeds also, we include both, until competent authorities decide the question.

CLASS II.—APERIANTHOUS ENDOGENS.

ALLIANCES.	*Orders.*
I. GLUMALES.	1. Graminaceæ; grasses. 2. Cyperaceæ; sedges. 3. Desvauxiaceæ; brittleworts. 4. Restiaceæ; cordleafs. 5. Eriocaulaceæ; pipeworts.
II. ARALES.	1. Typhaceæ, or typhads; bulrushes. 2. Araceæ, or arals. 3. Pandananceæ, or screwpines.
III. ORONTIALES (?)	1. Orontiaceæ.

Here again, De Jussieu and Lindley differ, the one placing orontiaceæ in this aperianthous class, while the other includes them with rushes in his alliance of juncales. Cyclanthaceæ are included in the pandanaceæ of Lindley; and pistaciæ or lemnads are placed here instead of with the previous class. *Restiaceæ* or cordleaves are also placed in this class by Ad. de Jussieu, although connected with arales in this class by Lindley.

CLASS III.—PERIANTHOUS ENDOGENS.

Alliances.	*Orders.*
I. Palmales.	1. Palmaceæ, or palms.
II. Xyridales.	1. Philydraceæ, or waterworts. 2. Xyridaceæ, or xyrids. 3. Commelynaceæ, or spiderworts. 4. Mayaceæ, or mayacs.
III. Juncales.	1. Juncaceæ, or rushes. 2. (Orontiaceæ, orontiads ?)
IV. Labiales.	1. Gilliesiaceæ; gilliesiads. 2. Melanthaceæ; melanths. 3. Liliaceæ; lilyworts. 4. Pontederaceæ; pontederads.
V. Orchidales.	1. Burmaniaceæ; burmaniads. 2. Orchidaceæ; orchids. 3. Apostasiaceæ; apostasiads.
VI. Narcissales.	1. Bromeliaceæ; bromelworts. 2. Taccaceæ; taccads. 3. Hæmodoraceæ; blood-roots. 4. Hypoxidaceæ; hypoxids. 5. Amaryllidaceæ; amaryllids. 6. Iridaceæ; irids.
VII. Anomales.	1. Musaceæ; musads. 2. Zingiberaceæ; gingerworts. 3. Marantaceæ; marants.
"Dictyogens." VIII. Dictyogenales (?)	1. Triuridaceæ; tailworts. 2. Dioscoreaceæ; yams. 3. Smilaceæ; sarsaparillas. 4. Philesiaceæ; philesiads. 5. Trilliaceæ; arids. 6. Roxburghiaceæ; Roxburghworts.

There is evidently some confusion in the minds of botanists with regard to classes and subclasses, alliances and orders, families and genera, species and varieties of plants. Some of Lindley's classes, such as *rhizogens*,

dictyogens, and *gymnogens*, are evidently groups of less importance than those of a class, or even a subclass. Many of his orders can hardly rank as more than families; nor is it necessary to give names of classes or subclasses to multitudinous groups, with little differences of organic structure. In the lower forms of nature, varieties are often very numerous without really constituting different species, and specific differences are abundant in each genus. In higher types we find some orders and alliances containing numerous families and species, while others have a single species only, with a few varieties. We cannot, therefore, give importance to mere names of groups, large or small, in botany, but place our natural groups together or apart, as leading differences may suggest, without undue regard to previous names and titles. The following synopsis is tentative, and will no doubt require some alteration, as our knowledge may increase.

We place the asteracial alliance in the highest rank of an organic scale; including calycifloræ as an articular type along with daisies, thistles, sun-flowers, etc. Bell-flowers form the next alliances subdivided into orders, each containing several series, which rank as alliances in Lindley's system. These belong to the epigynous subclass of Lindley, and may be left until we have dealt with the other subclasses, as he gives them.

1*st Subclass: Diclinous Exogens.*—According to De Jussieu's table, gymnogens and rhizogens are both diclinous exogens, and by including them in Lindley's diclinous subclass, we may discern three leading groups: one containing gymnogens alone; the other, nearly all the amentaceal diclines, which are either achlamydeous or monochlamydeous; and a third general group, which are monodichlamydeous or dichlamydeous. The coniferal alliance will thus include cycadaceæ, gnetaceæ, pinaceæ, and taxaceæ; the amental alliance will include amentales,

garryales, quernales, and as a near ally, the monochlamydeous urticales; the euphorbial alliance will include the monodichlamydeous groups of euphorbiales, cucurbitales, menispermales, with the dichlamydeous group of papayales, and the anomalous group of rhizogens.

2nd Subclass: Hypogynous Exogens.--This may form two main groups or general alliances, the one containing such orders as have the placentæ oxile, with an imbricated or twisted calyx or corocla; and the other, those in which these features are various or uncertain. Ericales, rutales, malvales, geraniales, sapindales, and guttiferales belong to the first of these alliances; piperales, chenopodiales, nymphales, silenales, violales, cistales, berberales, and ranales to the second.

3rd Subclass: Perigynous Exogens.—These contain two primary distinctions, the one being polypetalous, the other monopetalous; and each of these again may form two general alliances. Ficoidales, daphnales, rosales, saxifragales, and rhamnales, are both perigynous and *polypetalous,* or apetalous; gentianales, solanales, cortusales, echiales, and bignonales, are perigynous and *monopetalous.* Rosales and saxifragales seem most nearly allied, and may form one alliance of polypetalous or apetalous perigynes; ficoidales, daphnales, and rhamnales, another. Echiales and bignonales may form one of the monopetalous alliances; and gentianales, solanales, and cortusales, the other. Echiales might perhaps be subdivided into three divisions, under the names of jasminales, labiales, and boraginales; the first including jasminaceæ, salvadoraceæ, and brunoniaceæ; the second, lamiaceæ, verbenaceæ, myoporaceæ, selaginaceæ; the third, boraginaceæ, nolanaceæ, and ehretiaceæ. We need not dwell, however, on these points, as special science will have to deal with them more accurately.

4th Subclass: Epigynous Exogens. Here again, we

have a polypetalous and a monopetalous distinction of epigynous groups; and one of these, the monopetalous, contains an order which is higher than the rest in structure, and should form a separate alliance: this is the asteracial group to which we give the highest rank in the organic scale. The asteriacial epigynes, the monopetalous epigynes, and the polypetalous epigynes, form three alliances, then, in our arrangement; and, as the asarales form a most anomalous group of epigynes, being monochlamydeous, while the others are dichlamydeous, we give it an ambiguous rank analogous to that of bats in the organic scale of mammalia.

More knowledge is required to settle obscure points. Meanwhile, the general synopsis subdivides the great class of exogens into definite alliances, and families, which, being grouped in parallel divisions, under special heads and symbols, gives the memory a chance of easily recalling every main group of the whole class, and every series in each order.

In this arrangement we have dealt with general divisions only, leaving other questions to be dealt with by more competent authorities. Certain species may belong to other groups than those in which they have been placed by Lindley, who sometimes hesitates in his decision between one location and another; and where such changes are required, they will no doubt be made, eventually, by general consent. We leave them as they are, because minor groups and affinities are not affected by our primary distinctions.

INDIVIDUAL ORGANISM OF FLOWERING PLANT.

Z.	Supernal Forces, and Conditions.	H. *Embryonic supplies.* U. Climatic conditions. Ω. Food resources. O. Physiorganic forces.
Y.	Ingesta and Infesta.	H. *Impregnata and infesta.* U. Habitat in air, water, shade, marsh. Ω. Sap. O. Cambium and lacteal fluids.

X.	Secretions and Exuviæ.	H.	*Embryonic exuviæ: fruit, bulbs, bulbils.*
		U.	Glandular excretions.
		∩.	Feculant (starch, secretions, etc.).
		O.	Necrological exuviæ.
W.	Connective Tissues.	H.	*Skin of seeds.*
		U.	Glandular.
		∩.	Feculant.
		O.	Areolar.
VII.	Stem Vessels.	H.	*Germinal vessels: funiculus?*
		U.	Air vessels.
		O.	Lactiferous vessels.
		∩.	Eliminative vessels.
·7.	Leaves, etc.	H.	*Capillaries.*
		U.	Stomates.
		O.	Veins of leaves.
		∩.	Hair-ducts.
VI.	Roots.	H.	*Transitory roots.*
		U.	Receptive rootlets.
		O.	Digestive root ducts.
		∩.	Excretive root-ducts.
·6.	Rootlets.	H.	*Gland ducts? in roots.*
		U.	Ingestive pores?
		O.	Prodigestive ducts.
		∩.	Egestive pores?
V.	Fructifers.	H.	*Transitory forms of the germ.*
		U.	Anthers and ovaries.
		O.	Capsule or torus: fruit receptacle.
		∩.	Secretors of perigermal albumen.
·5.	Flowers.	H.	*Perianth: calyx, corolla, nectaries, etc.*
		U.	Style.
		O.	Stigma.
		∩.	
IV.	Medullary System.	H.	*Central pith.*
		U.	Leaf and fruit rays.
		∩.	Branch rays.
		O.	Stem rays.
III.	Heartwood.	H.	*Heartwood of spines.*
		U.	Heartwood of stem.
		∩.	Heartwood of branches.
		O.	Heartwood of collar.
·2.	Anomalous Branches.	H.	*Oak galls? etc.*
		U.	Spines.
		∩.	Fruit wood? seed wings, etc.
		O.	Tendrils.
II.	Alburnum.	H.	*Alburnum of spines?*
		U.	Alburnum of stem.
		∩.	Alburnum of branches?
		O.	Alburnum of collar?
·1.	Bark of Roots, Radiatory Organs, etc.	H.	*Bark of roots, etc.*
		U.	Prickles of stem?
		∩.	Hairs of leaves, etc.
		O.	Epidermis of stem.
I.	Bark of Stem.	H.	*Skin of fruit: pericarp.*
		U.	Bark of stem.
		∩.	Bark of leaves and fruit and spines.
		O.	Bark of collar.

COLLECTIVE UNITY OF PHANEROGAMIC REALM.

Z.	Supernal Conditions, etc.	H. *Embryonic supplies.*
		U. Climatic conditions and sphere of life.
		Ω. Food resources.
		O. Physiorganic forces, etc.
Y.	Ingesta and Infesta.	H. *Impregnata and infesta.*
		U. Housing, habitat, etc.
		Ω. Sap and air.
		O. Lacteal fluid, cambium, etc.
X.	Secretions and Exuviæ.	H. *Caducal fruit and leaves.*
		U. Glandular excretions.
		Ω. Feculent secretions.
		O. Necrological remains.
W.	Connective Classes.	H. *Anomalous and extinct endogens.*
		U. Perianthous endogens.
		Ω. Aperianthous endogens.
		O. Aquatic endogens.
VII.	Bellwort Alliance.	H. *Asarales.*
		U. Campanales.
		O. Cinchonales.
		Ω.
·7.	Cactal Alliance.	H. *Umbellales.*
		U. Grossales.
		O. Myrtales.
		Ω. Cactales.
VI.	Rosal Alliance.	H. *Extinct rosal types.*
		U. Chrysobolanaceæ ; calycanthaceæ.
		O. Rosales.
		Ω. Saxifragales.
·6.	Daphnal Alliance.	H. *Monopetalous rhamnales, stackhousiaceæ, [sapotaceæ, styracaceæ.*
		U. Rhamnales.
		O. Daphnales.
		Ω. Ficoidales.
V.	Hollywort Alliance.	H. *Extinct types.*
		U. Gentianales.
		O. Solanales.
		Ω. Cortusales.
5.	Labiate Alliance.	H. *Jasminaceæ, salvadoraceæ, brunoniaceæ ?*
		U. Echiales.
		O. Bignonales.
		Ω. Ehretiaceæ, nolanaceæ, boraginaceæ ?
IV.	Asteracial Alliance.	H. *Calyciforæ.*
		U. Liguliforæ.
		Ω. Labiatiforæ.
		O. Tubuliforæ.
III.	Coniferal Alliance.	H. *Cycadaceæ.*
		U. Gnetaceæ.
		Ω. Pinaceæ.
		O. Taxaceæ.
·2.	Euphorbial Alliance.	H. *Rhizogenales ?*
		U. Menispermales, papayales.
		Ω. Cucurbitales.
		O. Euphorbiales.

II.	AMENTAL Alliance.	H. *Urticales ?*
		U. Garryales.
		Ω. Quernales.
		O. Amentales.
1.	Ranunculacial Alliance.	H. *Violales, cistales.*
		U. Berberales.
		Ω. Ranales.
		O. Silenales.
I.	MALVACIAL Alliance.	H. *Nymphales, chenopodiales, piperales.*
		U. Rutales, ericales.
		Ω. Malvales, geraniales.
		O. Sapindales, guttiferales.

PHYSIOLOGICAL CHARACTERISTICS OF PHANEROGAMIA. —The physical, structural, and physiological characteristics of plants are as numerous and various as those of animals. Different *types* of trees and plants, *radiatory modes of action, permutations* of state, *vibratory modes of action*, different degrees in *complexity of structure, alimentary* peculiarities of *constitution*, and *nutritive modes of action*, different kinds of *vascular temperament*, and *vascular modes of action*, different *sexes* in plants, male, female, bisexual, hermaphrodite, and neutral, and different *modes of reproduction* by seeds, buds, and bulbils, are all as manifest in one organic realm as in another; but as all these questions are explained in standard works of botany, we need not dwell upon them in this outline of synthetical arrangement. We have but one observation to make, with regard to the supernal forces which give life to plants; and that is this, that physiorganic forces alone are manifest in plants; while instinctual forces are combined with these in all the animated realms. Physiorganic forces, then, are not convertible with physio-instinctual forces in the organism of a plant. It is not unimportant to mark this distinction, as some physiologists have attempted to show that the physical forces contained in food are essential to the manifestation of mental power in man, and that these two kinds of supersensuous forces, are not only correlative to this extent, but perhaps "convertible." The notion is unwarranted

by facts, and not indifferent from a religious point of view.

Physiorganic forces are manifested in connection with direct and retrograde metamorphic evolutions in plants; but they cannot be proved either to be latent in the germ itself, or to result from the development of heat in the chemical processes of elementary change, as modern theory would suggest, from shallow depths of thought.

OUTLINES OF CRYPTOGAMIC UNITY.

THE lowest organic realm being less developed in the individual, may be less complex in collective unity and multiplied diversity. The same organic functions are performed, however, by the lower types as by the higher, but with less complexity of structure and functional division of labour. In some cryptogams a simple cell performs all functions, while in higher types there is an axis with appendages of various kinds analogous to those of flowering plants. In ferns and lycopodiums there are stems and roots, internal vessels and external leaves; a relational and an organic mechanism more simple than in phœnogamic types, but still performing all the functions of organic life. There are rudimentary vascular, digestive, and reproductive systems. There is also a rudimentary woody system; a very simple derm or corticle, and a kind of medullary system in the central portion of the stem of some tree ferns. Soft fibres and cellular tissues form the main portion of cryptogamic plants in general. The roots are often a continuation of the stem, accompanied by what are called "adventitious roots", descending from the surface of the stem itself, and forming in tree ferns

an accumulated mass about the lower portion, in connection with the soil.

In these plants all the functions of organic life are necessarily performed, in an inferior degree, by organs which are rudimentary in structure; and therefore we must look for various functions and a limited diversity of structure both in the highest individual plant and in the whole collective realm. That part of the structure of a tree-fern which corresponds to the medullary system of a flowering plant, must take the highest rank in the rudimentary organism; and next to this we place the vascular system of the stem and leaves. After these the alimentary organs, however rudimentary, must claim attention; and next to them the very simple reproductive organs. These systems are more or less developed in the higher cryptogams; but in lower forms a very few simple cells and tissues suffice for all the functions. All the systems are, however, more or less developed in the higher types; and from this point of view the ferns are placed in parallel with the medullary and vascular apparatus; the lycopods with the digestive system; the mosses, properly so called, with the reproductive organs; and hepaticæ with the tissues of the stem.

Thallogens are placed in parallel with the connective tissues; and thus the simple unity of structure in a single organism becomes a type of unity in the collective realm.

Lindley observes that, "with all the habits of dorsiferous ferns, danæaceæ (or tree-ferns) are widely distinguished by the peculiar nature of their spore-cases, which are neither like those of ferns nor adders' tongues.....The entire want of that elastic ring which, in some state or other, so strikingly characterises *true ferns*, gives them (the danæaceæ) a far stronger title to be regarded as a distinct order than the trifling differences which in the eyes of some botanists elevated little groups of the latter to that dignity."

From our point of view, "tree-ferns" do form a distinct group of higher rank than common ferns, and by giving them a different name we should avoid confusion in our definitions and denominations. We adopt Lindley's subdivisions of the cryptogamic realm. He first divides *acrogens* from *thallogens*, to form two classes. He then subdivides each into three alliances; and these, again, into orders which seem very natural. His alliances of thallogens we rank as classes; while those of acrogens rank only as sub-classes, and are, indeed, unnecessary. We make no real change in Lindley's method by altering names of ranks and overlooking his sub-classes, while we recognise his natural orders and alliances.

In the highest individual cryptogam we recognise one class of primordial and three classes of connective tissues, the latter being *glandular* (secreting epiderm, mucus, etc.), *fecular* (secreting starch), and simply *cellular* (areolar and connective). The main class of tissues are chief elements of structure in the organic and relational systems of the plant.

Thallogens being inferior to acrogens are placed in parallel with the connective tissues; acrogens with those of the main class.

The first class of thallogens are the *algales* of Lindley; and these he subdivides into the following orders :

THALLOGENS.	*Natural Order of Algales.*
CLASS I.—ALGALES.	1. Diatomaceæ.
	2. Confervaceæ.
	3. Fucaceæ.
	4. Ceramiaceæ.
	5. Characeæ.

For all details concerning these orders, we refer the reader to Lindley's *Vegetable Kingdom.*

THALLOGENS.	*Natural Orders of Fungales.*
CLASS II.—FUNGALES.	1. Hymenomycetes, or agaricaceæ.
	2. Gasteromycetes, or lycoperdaceæ.
	3. Coniomycetes, or uredinaceæ.
	4. Hyphomycetes, or botrytaceæ.
	5. Ascomycetes, or helvellaceæ.
	6. Physomycetes, or mucoraceæ.

Thallogens.	*Natural Orders of Lichenales.*
Class III.—Lichenales.	1. Graphidaceæ. 2. Collemaceæ. 3. Parmeliaceæ.

The class of acrogens is subdivided thus by Lindley:

Alliances.	Orders.
I. Muscales. 1. Hepaticæ.	1. Ricciaceæ, or crystalworts. 2. Marchantiaceæ, liverworts. 3. Jungermanniaceæ, scale-mosses. 4. Equisetaceæ, horsetails.
2. Musci.	1. Andræaceæ, split mosses. 2. Bryaceæ, urn-mosses.
II. Lycopodales.	1. Lycopodiaceæ, club-mosses. 2. Marsiliaceæ, pepperworts.
III. Filicales.	1. Ophioglossaceæ, adders' tongues. 2. Polypodiaceæ, ferns. 3. Danæaceæ, danæaworts.

In dealing with the four subclasses of exogens established by Lindley, we had to subdivide them into secondary groups or alliances to form natural organic parallels. A similar plan will lead us to a very slight change in the arrangement of acrogens to form similar parallels. Eleven orders are recognised by Lindley, and some of these he further subdivides into sub-orders. To make a perfect scale of acrogens the natural divisions would be only twelve; and one of the eleven being already subdivided, gives us the whole number without doing violence to any natural distinction.

One question, however, arises in this case, and that is, the very imperfect structure of cryptogamic plants, and the absence of some organs highly developed in flowering plants. Are all the systems of a perfect plant rudimentally developed in any one or in several of the cryptogamic types? In the stem of a tree-fern there is a kind of pith, a kind of woody tissue, a kind of bark; and in some algals there are grasping feet, which fix the plants to stones or earth, and these, not being roots, are more or less analogous to tendrils and grasping organs in a flower-

ing plant. We have, then, in the stems of cryptogams a rudimentary development of all the systems of a phœnogam ; there are also regular and adventitious roots, analogous to the alimentary organs of a flowering plant ; vessels and fronds, analogous to vessels and leaves ; reproductive organs, analogous to those of higher types, but not developed as a flowering apparatus. Some botanists, however, claim as rudimental analogues of flowers the parts named *antheridia* and *sporangia* in hepatics ; *basidia* and *cystidia* in fungi. We may, therefore, give a perfect scale of functions to non-flowering plants, although the organs which perform these functions are but rudimental in structure. The parallel thus formed is only perfect in a functional point of view ; the structural development being necessarily as simple in the larger groups of cryptogams, and in the whole collective realm, as in the highest individual types or species of that realm.

The following synopsis seems quite natural, the highest types being made to represent the highest functions of the individual organism, and the lowest those which are more rudimentally developed both in structure and in function.

COLLECTIVE CRYPTOGAMIC REALM.

Z.	Supernal forces.	H. *Embryonic supplies.*
		U. Climatic conditions.
		∩. Food-resources.
		O. Physiorganic forces.
Y.	Ingesta, etc.	H. *Impregnata and infesta.*
		U. Investa, etc.
		∩. Recent absorptions.
		O. Circulating fluids.
X.	Exuviæ, etc.	H. *Spores, etc.*
		U. Gum, oil, etc., mucus.
		∩. Starch, etc.
		O. Necrological exuviæ.
W.	Thallogens.	H. *Extinct thallogens.*
		U. Class lichenales.
		∩. Class fungales.
		O. Class algales.

VII.	POLYPODIACEÆ.	Ferns (extinct and living).
·7.	Ophioglossaceæ.	Adders' tongues (extinct and living).
VI.	MARSILIACEÆ.	Pepperworts (extinct and living).
·6.	Lycopodiaceæ.	Club-mosses (extinct and living).
V.	BRYACEÆ.	Urn-mosses (extinct and living).
·5.	Andræaceæ.	Split mosses (extinct and living).
IV.	DANÆACEÆ.	Danæaworts (extinct and living species of tree-ferns).
III.	RICCIACEÆ.	Crystalworts (extinct and living).
·2.	Targioneæ (?)	Liverworts.
II.	MARCHANTIACEÆ.	Liverworts (extinct and living).
·1.	Jungermannaceæ.	Scale-mosses (extinct and living).
I.	EQUISETACEÆ.	Horsetails (extinct and living types).

PHYSIOLOGICAL CHARACTERISTIC OF CRYPTOGAMIA.—The physical, structural, and physiological characteristics of cryptogamic plants are less complex than those of flowering plants, but not, perhaps, less curious and various. There are very many different *types;* remarkable *radiatory modes of action;* various *permutations* of state; marked *vibratory modes of action;* some *complexity* of structure; different *nutritive constitutions* and *alimentary modes of action;* peculiar vegetable *temperaments* and *vascular modes of action;* and, although there are no very manifest distinctions of *sex,* there are great diversities in *reproductive modes of action.*

The words cryptogamic and non-flowering plants must be understood, in a qualified sense, applied to this whole realm; for, although we find no flowers, in the ordinary acceptation of the word, there are reproductive organs, containing fruit and seed, in this as in the phanerogamic type of vegetable organisms. These are more evident in what are commonly called fungi or mushrooms; that part of the "agaricus campestris" which is edible, being nothing but the fruit and seed of a mycelium or cryptogamic plant, which gives origin to the so-called mushroom, as an apple-tree gives origin to the fruit which bears its name.

"The *mycelium*," say botanists, "is composed of a number of very fine filaments, forming a kind of network, on which is developed the fleshy substance vulgarly known as the mushroom. The mycelium of an isolated agaricus bears a considerable resemblance to other vegetable productions, and to those kinds of mould or *mucor* which are formed upon decayed wood in damp and dark places. Seeing that they were propagated without any change of form, botanists have divided them into special groups, one of which is named *mucedinæ*. Some years ago, M. Dutrochet discovered that, under the influence of certain conditions, a well-characterised mucedina may produce an agaricus."

As in the lowest organic realm of the animal kingdom, the medusa, once considered as a distinct kind of animal, has been discovered to be the reproductive fruit and seed of a polype; so in the lowest organic realm of the vegetable kingdom, the mushroom, formerly considered as a special type of vegetable organism, is now discovered to be merely the fruit and seed of a mycelium.

The greater part of the substance of a fungus belongs to the fructificative system, the vegetative part being relatively small, consisting mostly of a few filaments or closely compacted cells. The reproductive bodies are of various forms, and grow in very different modes. In connection with the manner of vegetation, they form the most obvious characters of distinction for systematic arrangement.

"The common mushroom is the type of a very extensive group of fungi, characterised by an inverted cup (*pileus*), supported by a stem, and furnished on its concave under surface with a number of gill-like plates, arranged edgewise, which deposit, when placed on paper, a vast quantity of dust-like seeds or germs, commonly called 'spores.' These are of different colours in different

species, and, as the colours are accompanied by peculiar differences of habit in the plants, they afford a ready test for grouping species."

The Rev. M. J. Berkeley has published an excellent work on this branch of science, *Outlines of British Fungology, containing characters of above a thousand species of Fungi, and a complete list of all that have been described as natives of the British Isles.* There is a short review of this work in Weldon's *Register* for April 1861, from which we condense the following remarks.

"The greater proportion of fungi are of rapid growth, and of a soft cellular substance. They differ greatly in size, colour, and external appearance. Some are perfectly smooth, while many are clothed with silky or downy hairs, variously disposed, and highly ornamental. The brightest colours of the rainbow, combined with eleganee of form and delicacy of texture, adorn some species, while others are altogether unsightly.

"The common fairy-ring champignon is a familiar example of the first departure from the common mushroom type. It is much less watery, and can be preserved in a dry state for culinary purposes. The dædalia of the birch tree affords a good example of a still further hardening of the gills; while in that of the oak, the substance is as firm as a cork, and in some parts as hard as wood. All the true species of boletus are fleshy, and amongst them are the truffles of commerce. The polypori compose one of the largest genera, and exhibit, in their numerous species, every gradation, from great succulence to the hardness of wood. They are found in many places: a scaly kind on the common ash; a rough iron-stain kind on apple trees; a leathery kind, with velvety caps and many-coloured zones, is very common on stumps and felled wood; while a hard, hoof-shaped species abounds in plum orchards.

"Puff-balls are well known. The most beautiful are the starry puff-balls, which are comparatively rare. A large group of fungi, including multitudes of microscopic forms, is distinguished by their early character being creamy or mucilaginous; they differ in many respects from other fungi, and especially in appearing to be quite independent of the substance on which they are developed. One species, for instance, was discovered by Schweinitz growing on iron which had been red-hot only a few hours before. Specimens have also been observed growing on pieces of lead. But perhaps the oddest locality wherein specimens were ever discovered, was the crevices of cinders found on the outside of the dome of St. Paul's.

"In speaking of the *growth* of these plants, it should be observed, that fungi consist of two parts, the vegetative and the fructificative; the latter being the most apparent. In the common mushroom the vegetative part is represented by the *spawn*, and the fructificative by the stem, with its cap and gills. The spawn may spread for years without bearing any fruit, but fruit can never be produced without spawn. The spawn of fungi is generally found on bodies which are decaying, but not always; since it is sometimes found in the healthy tissues of plants. The rapidity with which it penetrates and the depth to which it enters, are often marvellous. Trunks of trees perfectly sound when felled, have been penetrated by spawn to within a few inches of their centre by the end of the second year. The dry-rot, so familiar in our timber and ship-yards, is only a species of fungus. In fir-built ships it is one species (merulius lacrymans), and in oak-built ships another species (polyporus hybridas). Sometimes the dry-rot is in the timber of a house without its presence being perceptible otherwise than by the faint sickening odour which it causes. It derives its popular name from the fact of converting the wood attacked by

it into a dry powdery mass, although both the wood and the fungus are often sprinkled with large drops of moisture.

"One of the most remarkable things about fungus invasion is, that it seems to pass through the closest and densest structures, and to find its way where the air is excluded. Thus fungi are found in the midst of potatoes, in cavities of the fruit of the tomato, and even inside eggs. They are found, too, at all altitudes and depths; on the summits of the Himalayas, 18,000 feet above the level of the sea, and as deep as man can reach in the bowels of the earth.

"A parasitical fungus of the genus *rhizomorpha* vegetates in deep mines, and is remarkable for its alleged phosphorescence in such places. This plant is said to grow in the deep coal-mines near Dresden and to spread over roofs and pillars and other parts of the pits, where it emits a visible and sometimes bright light; while at other times it is so subdued, as to resemble a soft moonlight. It is also said that the light increases with the temperature of the mines.

"A notable peculiarity about the growth of fungi, is the tendency to assume a circular disposition, seen in the fields in what are commonly called 'fairy-rings'. Sometimes these rings are of very ancient date and attain enormous dimensions, distinctly visible on a hill-side from a long distance. These, it is believed, originated from a single fungus, the growth of which renders the soil immediately beneath unfit for its reproduction. The spawn, however, spreads around, and next year produces a new crop, the spawn of which spreads again, and so increases the dimensions of the ring. If the spawn does not spread on all sides at first, an arc of a circle is produced instead of a complete ring.

"Enlarged acquaintance with this class of plants has

led to their discovery in all manner of strange habitats. They are most frequently found in putrescent logs of wood, damp walls, old cellar doors, wine vaults, old cupboards, washhouses, rejected clothing, etc. A fungus has even been found in the inside of a loaf of bread in Paris, a few hours after leaving the oven. The fact puzzled the Academy of Sciences; but after some research, it was ascertained that the spores of certain fungi will bear moist heat equal to that of boiling water, without losing their power of germination. The fungi have such powers of penetration and endurance that they frequently attack man's fruits and fields, and the loss of a crop or even a harvest may depend upon the prevalence of this neglected class of plants.

"A fungus has twice made Ireland tremble with fear. Seizing upon the tissues of the potato, its spawn attacks every portion of the plant, the tissues of the tubers and the stem as well as the leaves, inducing a rapid and complete decay; and no effectual remedy against the evil has been yet discovered. Some of the fungi which attack plants admit of easy extirpation by chemical substances, as their spores will not germinate after being treated in this manner; but others admit of no efficient remedy as yet discovered.

"Both man and the lower animals are subject to diseases caused by certain fungi. Silk-worms suffer from a disease called muscardine, from its converting them into a substance resembling a kind of pastile; and at the time of their death from this disease, they have their tissues completely traversed by the spawn of the fungus. A particular kind of fungus is developed on the body of a wasp in the West Indies while the insect is flying about, and within a few hours grows so large as to weigh the insect down to its destruction.

"All that we can infer with regard to the uses of this

numerous and irresistible tribe of plants is, that they are designed to hasten the destruction of decaying substances, so that the earth may not suffer long from the incumbrance and mephitic influence of decaying bodies, and that out of their remains may spring up new soil as a home for passing seeds, a new ground-work for living vegetation.

"Several of the fungi are useful in other ways, being edible and highly nutritive. The common mushroom and the truffle (boletus edulis) are well known, but these are not the only edible species. Many other kinds exist, which may yet furnish a considerable addition to our alimentary resources."

The four classes of cryptogamic plants afford a very interesting study for the naturalist, but we must refer to special treatises for special information. A few extracts from a review of the Rev. Hugh Macmillan's *Foot Notes from the Page of Nature* will convey a general idea of the vast importance of this organic realm in the present and past history of the earth.

"Time was when the entire surface of the earth was more bleak and bare than are now the loftiest peaks of the Andes, or the desert tracts of Africa ; no green thing clothed the rocks ; no living creature breathed the volcano-fed, mephitic vapours that spread over the waste of earth and water.

"The cryptogamic plants are supposed to be coevals of the earlier zoophytes, and anterior by countless ages to the huge amphibia of the 'secondary' geological period. For ages of ages before man appeared, these plants prepared the earth for his use and convenience, being the earliest of *soil-makers.*

"*Acrogenales.*—Among the first land-plants that appeared to act upon the dreary scene was, it is supposed, a species of lycopodium, closely allied to one of the com-

monest of our club-mosses. The period of its first appearance is computed to be coeval with that of the formation of such rocks, as are known by the names of greywacke and clay-slate.

"Plants disintegrate the rocks on which they grow, reducing the surfaces in course of time to powder. They also rearrange the constituents of the earth's surface into new chemical combinations, condense carbon out of the carbonic acid gas which they absorb from the atmosphere, and decompose the water which they derive either from the ground or from the vapour of the air. Vegetable matter is composed of carbon and three gases, nitrogen, oxygen, and hydrogen, together with some portions of inorganic matter derived from the soil or rock on which they grow. The increase of plants in size and weight is mainly due to their absorption of the elements which they elaborate into their own tissues. Every generation of plants, therefore, having condensed into a solid form the gases derived from air and water, and having combined these gases afresh with the elements derived from the soil, bequeaths to its offspring a richer soil than it lived upon itself. Plants thus absorb from the surrounding atmosphere its superfluous carbonic acid gas, retaining carbon and liberating oxygen ; and, by decomposing water, they also absorb hydrogen to liberate the oxygen, and thus enrich the air with oxygen required by animals for healthy respiration.

"No plants are so well guarded in these functions as the mosses. To them it matters not whether the temperature be that of a thermal spring (186° Fahrenheit), or that of a Melville island summer (35°). They may be buried for years under arctic glaciers, or dried for months in a botanist's herbarium ; yet give them warmth, moisture, soil, and the dry almost powdery filaments become green in a few hours, take root, and in due season develope their delicate fruit vessels.

"One species of moss peculiarly adapted to thrive in districts liable to excessive drought, rolls itself into a ball, and is carried immense distances by the winds. Conveyed to a moist place, it takes root, fructifies, casts its seed abroad, and will be ready for a new aërial voyage when water again fails. Not being eaten by herbivorous animals, nor liable to the attacks of beetles or other insects, some species of the moss tribe enjoying these immunities have seen the rise and survived the decline of species after species of plants, ranking higher than themselves in the botanists' classification of fossil plants, subserving a less permanent use.

"The club-mosses of old sometimes attained a height of eighty feet. Their forests once stretched almost uninterruptedly from Melville Island in the extreme north, to the Antarctic limits of the Southern Ocean. They seem to have lived in luxuriant growth from the period of the clay-slate of the Silurian age, through the Devonian, up to their culminating point, in the great coal period or carboniferous age. Here they excel, in the ornate markings of their stems, any tree of the present day; for the beautifully star-studded and figured coal-trees, such as the stigmaria, the sigillaria, and the lepiodendra, are but the humble mosses at their acme of development.

"The peat-beds, sometimes twenty feet thick, which occupy a tenth of all Ireland, and a considerable part of the Highlands of Scotland, are mostly the remains of the bog-moss, or *sphagnum*. This species, sometimes growing to a length of six or seven feet in deep water, occupied shallow inland lakes, which by degrees, through successive decay of the lower parts of the moss, and the growth alone of more, were converted into quaking bogs, green with moss on the surface, and filled beneath with the accumulations of the decayed plants; the whole in the lapse of ages consolidating it into peat, so useful as fuel, soil, and manure.

"From the astonishing luxuriance of fern-like plants allied to the mosses and the equisetums, especially at the end of the coal era, and the total absence of any highly organised air-breathing animals, it becomes highly probable that the atmosphere was, during the greater portion of the early periods, densely loaded with carbonic acid gas, and wholly unfit to be respired by any of the higher vertebrata.

"Some species of mosses are confined to certain kinds of rocks, to special localities, or to places within certain lines of equal temperature. The Alpine species are not found lower than the altitude of three thousand feet above the level of the sea, on British mountains. On the Pyrenees, and on the Alps of Switzerland, they reach a height of eight thousand feet. Yet the same species clothe the plains of Lapland and the sea shore of the Arctic regions, both being isothermal with the mountain altitudes just mentioned.

"All the Alpine plants found on the summits of our loftiest hills are Norwegian or Arctic species. There is a genus of moss, called splachnum, found exclusively on the bleaching bones or other remains of animals; and this moss is said to be the only vegetable whose origin is contemporary with, or posterior to, the creation of animals, with the exception of microscopic entophytes, growing within the bodies of men and the lower animals. Some mosses are confined to calcareous soil, some to granite, others to beds of micaceous schist. Wherever they grow they abstract moisture from the air, besides condensing carbon, and prepare the soil for the growth of higher orders of plants, which serve the wants of animals.

"The sporules, or minute seeds of mosses, are encased in capsules, and elevated on stems. At the orifice of each capsule, there is a fringe of delicate teeth or filaments, which are so highly hygrometrical as to close in-

stantly if breathed upon. In warm dry air they will again unlock their clasps. These cilia or teeth of the seed capsules are always in even numbers; and when they occur in rows, the numbers are always four, eight, sixteen, thirty-two, sixty-four, etc., in geometrical progression. Each capsule is protected by a closely fitting cap, and has another over this, resembling an old-fashioned nightcap. These fall off when the spores are ripe, and the seed vessel then bends itself and pours out its treasures to the wind, as seeds might be poured from a pitcher.

"Liverworts are the hardiest of their class. They have no seed vessels, like the urn mosses, but they have filaments mingled with the yellow mass of their seeds, which by a jerking motion, probably of hygrometric origin, expel the ripened seeds with much force. These plants are so small in some species as to be hardly visible; while some of the club mosses, at the present day, attain the height of trees in New Zealand.

"The organs of fructification in mosses are sexual, though flowerless. The antheridia and pistilidia, analogous to stamens and pistils in flowering plants, grow upon the leaves, near the seed capsules, which they vivify. There is, however, one remarkable species of moss, of which the male is found only in Europe, and the female in America, and yet they propagate their species with as much facility as if they grew side by side in the same crevice of a rock.

"The mosses are now mostly expunged from the *Pharmacopœia,* though a few are still retained for their strongly cathartic properties. The lycopods, or club mosses, are employed with alum, in the Highlands of Scotland, as a mordant in dyeing tartans, and the moss is also used alone to impart a blue tint. The seeds of these mosses are very inflammable, and, being ignited, are

blown through tubes at theatres to imitate lightning. In Lapland, mosses are sometimes used to prepare couches, and as wrappers for new born babes. They cannot be considered of great importance in modern uses; but they have been highly important in past ages, in forming vast beds of peat, and in preparing the earth as an abode for higher races.

"*Lichenales.*—The lichens have, perhaps, a more extensive range than mosses. They cling in dark green, yellow, or brown patches to the bare summits of high mountains, and remain immovable through the storms of numberless winters. They alone of living things are found on that great antarctic glacial ridge which bars the southern pole to the extent of some four hundred miles. They are also found in tropical climes, though unable, as in desolate regions, to compete for place with the higher forms of vegetation. There are no plants so slow of growth, so tenacious of life, or so economic in their requirements of warmth and soil, as the lichens. A plant of this class, that was watched by an observer over a period of more than twenty-five years, underwent no perceptible change during that time. From the continuous extent of these slow-lived plants along the ridges of mountains, and from their position covering the striæ made by floating icebergs upon these mountain tops during the glacial period, it is supposed that individual lichens now living are so ancient that no geologist would venture to limit their age to thousands of years.

"Although lower in the scale of organisation than mosses, lichens are more immediately serviceable to man. In Lapland they furnish the only food of the reindeer, which is of more importance to the natives than other animals to any other race of men. Lichens are also valuable in commerce, as colouring matter used in dyeing stuffs of various kinds. Orchil is prepared from a species

of lichen found, in its highest perfection, in the Cape Verde Islands, and sold at the rate of £200 a ton. An inferior kind is found in many other places, but does not sell for more than £30 a ton. Litmus is made from orchil, and generally used as a test for acidity in analytical chemistry. The cudbear, a lichen indigenous in our own island, affords a dye equal to that of orchil. The common yellow wall lichen yields a colouring matter identical with that of rhubarb, and answers as a cheap substitute for the expensive foreign litmus. Lichens also possess, in common with clarified lard, the remarkable property of absorbing and retaining odours, and are therefore, although generally scentless themselves, much used as a base in many perfumes. They abound in oxalic acid, which seems to be to them what carbonic acid is to corals and calcareous shells. Much of the oxalic acid of commerce is derived from lichens.

"Iceland moss, as the lichen cetraria islandica is called, grows abundantly on the lava of the western coast of Iceland. It is carefully collected by the natives once in three years, to be ground and used as we use flour, after having first deprived it of a bitter principle by macerating it with water and quicklime. Other lichens have served man as food, in cases of great need. In 1829, during the war between Persia and Russia, there was a famine in Oroomiah, south-west of the Caspian Sea. One day, during a violent wind, the surface of the country was covered with a lichen, which fell in showers from the sky. The sheep immediately devoured it, and that suggested to the inhabitants the idea of reducing it to meal and making bread of it, which was found to be palatable and nutritious. During the siege of Herat, more recently, the papers mentioned a hail of manna, which fell upon the city and served as food for the inhabitants. Several instances are recorded of this lichen, which grows to the

size of a pea, unattached to the soil, being conveyed to great distances by strong winds, and showered down upon the earth.

"One minute species of lichen, the lepraria tolithus, is of a blood red colour, and abounds upon the stones around Holywell, in North Wales, where it is fabled to be the blood that dropped from the head of St. Winifred the Martyr. Some lichens are most beautifully marked by little coloured lines and patches resembling Arabic or Chaldaic characters. Lichens supposed to be injurious to the trunks and branches of trees, which they warmly clothe against the searching winds of winter, throughout whole forests in some regions, are really a great protection to them; for although they are attached by slender roots to the bark of the trees, they derive their sustenance almost entirely from the moisture and the gases of the atmosphere. As to the lime with which oxalic acid is found combined in lichens, it may be derived from calcareous dust; and as oxalic acid is but carbonic acid deprived of a fourth of its oxygen, that is certainly obtained from the air.

"*Algales.*—The fresh-water algæ are lower in the scale of vegetation than the lichens. The green slimy matter which, during spring and summer months, creams upon the surface of the stagnant pool, is found, when examined under the microscope, to consist of delicate filaments crossing and interlacing in all directions. These filaments are transparent tubes containing the fructification, consisting of minute green cells or 'endochrome'. When two filaments approximate, each throws out from one side a small process which unites with a corresponding process from the side of the other. The two ends unite, and the interval between the plants is thus bridged over by a transverse tube. The endochrome of the one cell then passes through the communication thus formed into the

other, and the contents become mingled in a round mass, to form the seeds or spores which reproduce the species.

"Another instance of apparent voluntary motion in the algæ, is presented by the oscillatoriæ, whose filaments oscillate violently, however much removed from every known cause of agitating impulse. One species of this alga is found in blue mould-like patches on the damp walls inside some churches in Suffolk. Another variety abounds on the Himalayas at an elevation of 18,000 feet. The decaying plants of some varieties give out a poisonous smell of sulphuretted hydrogen. Few of the algæ are long-lived as individuals, their cycle of existence being limited in some cases to a few days, and is seldom prolonged beyond a year.

"For wideness of distribution, multitude, and important share of work in nature's vast laboratory, there is no tribe to compare with the diatomaceæ or brittle-worts. The calcareous and siliceous coverings of these microscopic atoms cover the bed of nearly every ocean, sea, lake, river, and stream upon the globe. A dab of mud from the tops of the highest British mountains may contain millions of these remains, and numerous species have been detected by Ehrenberg on the few particles of soil adhering to the roots of some exotic plants. From the icy barriers of the Antarctic Ocean to the limits of discovery at the north pole, diatoms abound. The Yellow Sea owes its colour to the prevalence of these living atoms, which also give decided tints to other vast ocean tracts, while their fossil exuviæ constitute entire strata in some portions of the earth's crust. It is remarkable that some of the oldest fossil diatoms are of existing species. We have seen that certain mosses and lichens are of much greater antiquity than any known species of higher organisation, and at the bottom of the scale in this lowest class of the cryptogamic realm, we find the families to be

still more persistent. A kind of clay called caonac, consisting almost entirely of diatoms, is eaten by the natives of Guinea: they constitute the unctuous clay eaten by the Otomacs on the shores of the Oronoco and the Meta. Chinese annals are said to contain accounts of 'fossil flour' eaten by the poor in times of scarcity, as the 'bergmeal' is eaten by the Swedish Laplander: and both consist of the fossils of these microscopic algæ. The meerschaum of Turkey, and the polishing slate of Berlin, contain millions of fossil diatoms in every cubic inch. Certain species of the diatom are peculiar to the ocean: some to rivers; others to fresh-water lakes, or to the land. The geologist may thus, aided by the microscope, in many instances determine the manner of formation in ancient strata by the species of diatomaceæ which they contain. The manner in which these living atoms secrete calcareous or silicious matter from the surrounding elements in which they live, is not explained. Their subtle chemistry is beyond the ken of human chemist."

THE ATMOSPHERIC REALM.

Classes and Alliances of Climatic Strata.—The atmospheric realm may first be divided into several distinct classes; *i.e.*, a primary synorganic class of strata, in which animal and vegetable life can be maintained; and three secondary classes which are quite unfit for life of any kind. The synorganic strata extend to a height of some five miles or more in equatorial regions, and descend to the level of the sea in Arctic regions. The strictly polar atmosphere is quite unfit for life, and forms the first azoic class of strata. The next azoic class is that immediately above the synorganic class in equatorial and

temperate latitudes, and this is mainly the region of meteoric phenomena. The clouds, however, cannot ascend to heights exceeding thirty miles, it is believed, while the atmosphere itself attains a height of fifty or seventy miles. The highest regions form a third class, then, of azoic strata.

As little, or nothing, is known of the peculiar structure of the atmosphere in the secondary classes, beyond the fact of being unfit for animal and vegetable life, we cannot analyse them as we do the secondary classes of other realms; and therefore we shall briefly notice the synorganic class alone.

Chemically analysed, the elemental structure of the air may be much the same at all the altitudes where animals and plants can live and thrive; but there are differences of constitution in each strata, which fit them respectively for certain kinds of life, and unfit them for other kinds. Certain animals or plants alone can live and thrive in the highest Alpine regions or the coldest Arctic latitudes. A different range of latitude and altitude is fit for other tribes of animals and plants; while lower strata suit a different set of organisms; and the lowest are most genial to a different fauna and flora from those of higher strata. We may first divide the atmospheric strata, therefore, according to the limits suitable to different kinds of fauna and flora, taking isothermal lines of demarcation as the boundaries of each. The snow line altitudes of equatorial regions and of Arctic latitudes, form one natural limit; the sea level of temperate regions, and its isothermal altitude at the equator, a second; the sea level in the warmer latitudes with corresponding altitudes within the tropics, a third; and those of the tropics themselves, a fourth.

There are also different expositions in each latitude and altitude, which are favourable to one federation of fauna

and flora, and not to others. These may be exceptionally warm in Arctic latitudes, or exceptionally cool in equatorial latitudes and longitudes. The most general distinctions of synorganic strata, are *frigid*, *temperate*, *tropical*, and *equatorial*. Exceptional expositions in temperate latitudes may be as cold as Arctic regions, while some exceptional regions in the colder zoic latitudes may be as warm as temperate strata. There are longitudinal expositions also, in all latitudes, which form exceptional regions, in adaptation to distinct federations of fauna and flora, such as those, for instance, which characterise the Australasian, the South African, and the South American continents, in equal latitudes.

Four general distinctions of climate are described in Keith Johnstone's *Physical Geography:* and these are designated as—"1st, in the northern hemisphere, the climate of *mosses* and *berries;* 2nd, that of *European grains* and *forest trees;* 3rd, that of *European* and *tropical grains* and *fruits;* 4th, that of *tropical grains, palms*, and *bananas*." These may easily be carried further in a scale of natural delimitations. Two leading divisions may be made for the tropical and the extra-tropical climates; and each of these may be subdivided into natural zones of atmospheric regions, suitable to different federations of flora and fauna. There are *torrid*, *ardent*, and *tropical* regions within the so-called tropics; and there are *genial*, *temperate*, *variable*, and *frigid* climates, in the extra-tropical latitudes and altitudes. These are the most natural alliances of climate, supplemented by inosculatory regions, peculiar and subordinate to general alliances. There are torrid expositions beyond the limits of the torrid zone, and also ardent and tropical expositions beyond the limits of these zones. There are climates which are intermediate between the frigid and the variable, and also between the variable and the tem-

perate. From temperate to genial there is no intermediate step; and thus we have a natural scale of twelve atmospheric zones and climates, parallel with the chief natural orders and alliances of other realms. It is the adaptation of these different zones of latitude and altitude to different federations of fauna and flora, which constitutes at once the basis of distinction in the structural characteristics and the functional uses of synorganic climes.

Functional Factors of each Special Region.—The constitution and functions of the air in every clime, run parallel with the structure and functions of an individual organism in any class or species. In every animal there are *digestive, vascular*, and *reproductive systems*, as well as *cutaneous, muscular, osseous*, and *nervous systems.* These terms must be translated into others before we can form true parallels between the inorganic and organic realms. We shall not find skin, muscles, bones, and nerves in atmospheric regions; but, as the skin is a *limitative* factor, the muscles an *oscillative* factor, the bones a *resistive* factor, the nerves an *electro-telegraphic* factor in the animal organism; so we may find limitative, oscillative, resistive, and electric factors in every special region of the atmosphere. The genetic system of an animal is *reproductive*, the digestive system is *assimilative*, the vascular system is *circulative;* and corresponding factors may be found in every inorganic realm. In all the regions of the air we may observe circulation, commingling ingestion, and regeneration; electric tension, tidal oscillations, resisting densities, and special limitations of all these functional and structural distinctions. As these constituent factors are found in every individual organism, they belong to every order and alliance of an organic realm; and so of inorganic realms, the same special factors belong to the most limited regions and the most extensive zones.

In addition to the general distinctions of zones and latitudes which are more or less permanent, we may notice the circulation of atmospheric currents in numerous directions, the alimentation and depuration, as it were, of each latitude, by the introduction of fresh air, and the removal of stale air; not to mention the loss of oxygen by the respiration of animals, and the gain of oxygen by that of plants, involving as they do the chemical death and regeneration of a certain amount of atmospheric air in all these operations where life exists and air is decomposed.

There are decompositions of atmospheric air where oxygen is separated from nitrogen in all the realms, and reproductions of atmospheric air when oxygen and nitrogen are recombined in due proportions. There are ingestions of fresh air from polar and other latitudes into the synorganic strata, by means of upward and downward currents; and there are translations of fresh air by lateral currents in the same altitudes and latitudes. We may, therefore, recognise the laws of order and number in a scale of structural and functional characteristics in both inorganic and organic realms. Circulation, ingestion, and genesis occur in every region of the air; and where free oxygen is in excess the region may be compared with one sex, while air surcharged with free nitrogen may be compared with the opposite sex; the union of two such local masses giving birth to a combination of oxygen with nitrogen, to reproduce the atmospheric species.

If this comparison be legitimate, we have the natural parallel of sexes in the local regions of the air, and a complete scale of functions in the factors of each region. The special connectives are the simple gases oxygen, nitrogen, and hydrogen, floating uncombined in every locality. Where these are combined with other elements to form carbonic acid and ammonia, they belong to the

pluvial realm, and no longer serve as connective elements of the proper atmosphere.

We have, then, in every special region of the air, however limited in mass, *circulatory, ingestive, genetic, limitative, resistive, oscillative,* and *electric* factors, corresponding to the seven systems of an individual organism, and free connective elements floating in the air, as the connective tissues permeate the organs of an animal or plant. Inosculatory factors may also be defined in parallel with the vibratory, the radiatory, and other factors of organic nature, but these being faintly marked may be omitted in a general outline.

From the scale of individual factors and functions in local masses of the air, we may return to that of general zones and classes; the laws of order and degrees being manifest alike in collective and in local masses of the atmospheric realm, as in the individual and collective organisms of other realms. In every class of atmospheric zones there are two hemispheres, austral and boreal, in contrast with each other as polar opposites, although identical in form and character. The direct parallel between the hemispheres of any realm and those of an individual organism is that of polar development: the diaphragm being the equator of the human body, while the cranium and the pelvis are the polar extremities. In boreal animals the cranium is often more developed than the pelvis; while in austral types, such as the kangaroo, the pelvic regions are much more developed than the cranial. The pelvic region is the sexual in animals; but whether or not any sexual analogies contrast the austral with the boreal hemispheres of the atmospheric realm it would be useless to conjecture. The special uses of the natural zones in either hemisphere is a simpler question, and one more easily dealt with.

Fauna and Flora of different Zones.—It is not within

the reach of our limited knowledge of the different flora of each zone, to determine accurately what are the most characteristic fruits and grains of every clime, but a general approximation will suffice for our present purpose, and this may be nearly as follows:

Pepper and spices seem to be most characteristic of the torrid zones; pine-apples and bananas of the ardent zones; cotton, indigo, and sugar of the tropical zones. Many other kinds of plants and fruits are common in these latitudes, and some may be more characteristically indigenous to them respectively than those here mentioned; but an indication of their climatic peculiarities is all we seek for. The orange grows most naturally in a genial climate; the peach, the almond, the olive, and the vine in temperate zones; wheat, pears, and apples in a variable climate; berries and mosses in a frigid zone. Barley, oats, and rye are found in climates intermediate between the frigid and the variable; chestnuts and oaks between the variable and the temperate; rice is abundant in genial and subtropical regions; coffee and date palms in subardent regions; cinnamon and bread fruit in subtorrid climes.

Inland and insular positions, along with numerous other circumstances and conditions, give various directions to isothermal lines; and the study of climatology, as a special science, is necessary to complete the outlines here suggested.

Longitudinal Distinctions.—The subdivisions of each zonal climate are diversified by longitude: the Asian Australasian, Europe African, American, and Oceanic being the natural distinctions of climatic longitude upon our globe. Asia and Australasia belong to the first; Europe and Africa to the second; North and South America to the third; the North and South Pacific Ocean, with its numerous islands and New Zealand, belong to

the fourth. The natural products of the seven general and the five inosculatory zones, are more or less different in each of these cardinal longitudes; and a thorough investigation of physical geography and climatology will show the differences between the peculiar characteristics of each definite zone and longitude in the two contrasted hemispheres. We need not dwell on these details, but give at once an outline of the natural alliances and orders, series and groups of atmospheric zones and climates, as adapted to the uses of all other epicosmic realms, and more especially to the various products of the vegetable kingdom; observing, however, that latitudes and altitudes are convertible terms in climatology.

Altitudinal Distinctions.—In a chain of snow-capped mountains, attaining to the height of some five miles, under the equator, we may find all the climates of the globe, proceeding upwards from the torrid level of the sea to the frigid regions of the snow. Proceeding polewards, north or south of the equator, at the level of the sea, we travel likewise from the torrid to the ardent, the tropical, the genial, the temperate, the variable, and the frigid latitudes, until we reach the Arctic and the Polar circles: and all the products of the earth may be obtained by travelling skywards in altitudes under the equator, or polewards in latitudes from the equator.

Distribution of Plants.—On this question the reader may find some excellent remarks in Mrs. Somerville's work on *The Connection of the Physical Sciences*, sect. xxvi. "The gradual decrease of temperature in the air and in the earth from the equator to the poles," she observes, "is clearly indicated by its influence on vegetation. In the valleys of the torrid zone, where the mean annual temperature is very high, and where there is abundance of light and moisture, nature adorns the soil with all the luxuriance of perennial summer. The palm,

the bombax ceiba, and a variety of magnificent trees, tower to the height of one hundred and fifty or two hundred feet above the banana, the bamboo, the arborescent fern, and numberless other tropical productions, so interlaced by creeping and parisitical plants, as often to present an impenetrable barrier. But the richness of vegetation gradually diminishes with the temperature; the splendour of the tropical forest is succeeded by the regions of the vine and the olive; these, again, yield to the verdant meadows of more temperate climes; then follow the birch and the pine, which probably owe their existence in very high latitudes more to the warmth of the soil than to that of the air. But even these enduring plants become dwarfish shrubs, till a verdant carpet of mosses and lichens, enamelled with flowers, exhibits the last sign of vegetable life during the short but fervid summers at the Arctic regions. Such is the effect of cold and diminished light on the vegetable kingdom, that the number of species growing under the equator and in the northern latitudes of 45° and 60°, are in the proportion of the numbers twelve, four, and one.

"By far the greater number of the known species of plants are indigenous in equatorial America; Europe contains about half the number; Asia, with its islands, somewhat less than Europe; Australia, with the islands in the Pacific, still less; and in Africa there are fewer known vegetable productions than in any part of the globe of equal extent, for that rich and luxuriant region discovered by Dr. Livingstone has yet to be explored botanically. Very few social plants, such as grasses and heaths, that cover large tracts of land, are to be found between the tropics, except on the sea-coasts and elevated plains. Some exceptions to this, however, are to be met with in the jungles of the Deccan, etc. In the equatorial regions, where the heat is always great, the distribution of plants

depends upon the mean annual temperature; whereas in temperate zones the distribution is regulated, in some degree, by the summer heat. Some plants require a gentle heat of long continuance, others flourish most where the extremes of heat and cold are greater. The range of wheat is very great. It may be cultivated as far north as the sixtieth degree of latitude; but in the torrid zone it will seldom form an ear below an elevation of 4,500 feet above the level of the sea, from exuberance of vegetation; nor will it ripen generally above the height of 12,000 feet. In Thibet it ripens at a still greater elevation. Colonel Sykes states that, in the Deccan, wheat thrives as low as 1,800 feet above the sea. The best wines are produced between the thirtieth and forty-fifth degrees of north latitude. With regard to the vegetable kingdom, elevation is equivalent to latitude as far as temperature is concerned. In ascending the mountains of the torrid zone, the richness of the tropical vegetation diminishes with the height: a succession of plants similar to, though not identical with, those found in latitudes of corresponding mean temperature takes place: the lofty forests by degrees lose their splendour, stunted shrubs succeed, till at last the progress of the lichen is checked by perpetual snow.. On the volcano of Teneriffe there are five successive zones, each producing distinct families of plants. The first is the region of vines, the next that of laurels. These are followed by the region of pines, the region of heaths, and that of grass; the whole covering the declivity of the peak through an extent of 11,200 feet of perpendicular height.

"Each separate region, both of land and water, from the frozen shores of the polar circles to the burning regions of the torrid zone, possesses a flora peculiarly its own. The whole globe has been divided by physical geographers into various botanical districts differing almost entirely

in their specific vegetable productions, the limits of which are most decided when they are separated by a wide expanse of ocean, mountain chains, sandy deserts, salt plains, or internal seas. A considerable number of plants are common to the northern regions of Asia, Europe, and America, where the continents almost unite; but in approaching the south, the floras of these three great divisions of the globe differ more and more, even in the same parallels of latitude; which shews that temperature alone is not the cause of the almost complete diversity of species that everywhere prevails. The floras of China, Siberia Tartary, of the European district including central Europe and the coast of the Mediterranean, and the oriental region comprising the countries round the Black and Caspian seas, all differ in specific character. Only twenty-four species were found by MM. Humboldt and Bonpland in equinoxial America, identical with those of the old world; and Dr. Robert Brown not only found that a peculiar vegetation exists in Australia, between the thirty-third and thirty-fifth parallels of south latitude, but that at the eastern and western extremities of these parallels not one species is common to both, and that certain genera also are almost entirely confined to these spots. The number of species common to Australia and Europe are only 166 out of 4,100, and probably some of these have been conveyed thither by the colonists; but the greater part of that continent is still unexplored. However, this proportion exceeds what has been hitherto observed in southern Africa, and the proportion of European species in equinoctial America is still less."

More special details on all these questions may be found in standard works of botany and physical geography; but these are sufficient for a general outline of atmospheric zones of latitude and longitude adapted to particular federations of fauna and flora in each special region.

Organic Unity of Atmospheric Realm.—We cannot speak of this with any certainty. All we can do is to shew that there are three classes of azoïc strata quite unfit for animal and vegetable life, although the germs of animals and plants are carried up to meteoric regions to be wafted over immense areas of space, and finally deposited in distant climes of sea and land. No organic life is known above the height of six miles in our atmosphere. The class of strata between the life-limit and the cloud-limit is an azoïc class differentiated by degrees of functional energy in meteoric phenomena of various kinds. The cloud-limit reaches to a height of thirty miles or thereabouts; and another class of azoïc strata ascends to the computed limit of the atmospheric ocean, supposed to average a height of fifty miles. Beyond the appearance of northern lights in our hemisphere, and similar phenomena in the austral hemisphere, above these highest strata, or within their limits, nothing is known of the functional peculiarities of the different strata in this auroral class of azoïc atmosphere. We cannot analyse the successive strata of this class, or indicate their different characters and uses. The strictly polar class of azoïc atmosphere extends from the poles to the incipient limits of the arctic and antarctic circles, where animal and vegetable life begin in their lowest forms. This class may not include more than ten or twelve degrees of latitude; for certain forms of life are found in the highest arctic regions. We cannot, however, suppose that either animal or vegetable life extends to the very poles themselves.

What may be the special characters and uses of concentric strata from the Arctic limits of 80° to the Polar limits of 90° we cannot divine. There are, however, three azoïc classes of atmosphere, and several alliances in each of these; but what the nature and the uses of these different strata in each azoïc class may be, we leave to future observation and induction.

In the *Romance of Natural History*, by Philip Henry Gosse, there are many interesting facts recorded of organic life in different latitudes, and some of those observed within the limits of the Arctic region, bordering on the Polar circle, are very curious; while others tell of life amidst extreme conditions of heat, which are equally astonishing. "Sir Thomas Ackland found beautiful flowers, and a thicket of dwarf birch and osier, with mosses, lichens, and a variety of small herbaceous plants upon the snow-covered sides of the crater of the dormant volcano Schneehätten, the highest mountain in Norway and Mr. Atkinson, in the valley of the Black Irkout, in Eastern Siberia, saw large poplar trees, in full leaf, growing through a bed of ice and snow fully twenty-five feet in thickness. The trees had thawed the ice to a distance of nine inches from their stems, so that for that distance each trunk was surrounded with water; but, with this exception, all around was hard frost. On the other hand, Humboldt has recorded that when he visited the hot springs of Venezuela, the temperature of which is 194° Fahrenheit, the vegetation around seemed to rejoice in the heat, being unusually luxuriant, the mimosas and fig trees spreading their branches far over the hot water, and even pushing their roots into it. In the burning deserts on the Pacific Coast of South America lichens grow abundantly on the surface of the hot sand, entirely unattached by any root; while in the Karroes of South Africa, nearly as arid as the Sahara itself, succulent plants, such as euphorbias, stapelias, mesembryanthemums, crassulas, and aloes grow in considerable abundance, each plant maintaining its hold upon the sand by the weak support of a single slender, wiry root, and probably fed, like the lichens of the South American deserts, almost entirely from the atmosphere and the dew. These Karroes also produce plants with stalks no thicker than a

crow's quill, but with tuber root as large as a man's head, and filled with a liquid deemed by the natives a deliciously cool and refreshing drink.

"Wonderful as it is to find living animals in strong brine, in nearly boiling water, in scorching hot sand, or amidst perpetual frost, the immense distances which minute and delicate creatures can travel through the air without receiving harm are hardly less surprising. Clouds of 'dust,' sometimes so dense as to darken the air, are often encountered far out at sea; and this dust, which frequently falls in such quantities as to hurt people's eyes, and soil every thing on board ship, is found upon examination to consist almost entirely of living infusoria. These are known to come from shore, being mostly of a kind peculiar to fresh water; and it is supposed they are wafted in most cases from Africa, since they are never met with except in the season of the African wind called the 'harmattan,' which travellers have always described as remarkable for raising clouds of dust very high into the air. If this supposition be correct, there are instances on record in which these clouds of infusoria must have travelled at least sixteen hundred miles. Even dragon flies have been met with six hundred miles from shore, and a butterfly has been seen on board ship twelve hundred miles from the coast whence it must have come, and after so long a journey was active enough to avoid capture. Nearer shore, butterflies are sometimes observed in enormous multitudes. About ten miles from the mouth of the river La Plata, Mr. Darwin saw a flock so numerous and extensive that the telescope could discover no spot free from them, and the seamen said it was 'snowing butterflies.'

"Lizards and beetles abound in the burning sands of the Sahara desert; eels exist in the hot springs of Aix, the temperature of which is 113° Fahrenheit. Hum-

boldt found living fishes in full health and vigour thrown up from the crater of a volcano in South America with steam and water, only two degrees below the boiling point. In Canada, numerous insects, never seen at any other season than that of winter, hop about upon the snow; and on the shores of Baffin's Bay, within the Arctic regions, Ross observed a range of cliffs which for eight miles appeared to be hung with crimson cloth, this appearance being due to the snow with which the cliffs were covered, to the depth of twelve feet, containing incalculable myriads of little globules, believed to be the eggs of a minute but highly organised animal, also found in the glaciers of the Alps."

From this it appears that the germs of organic life may be found in the extreme limits of the Arctic regions, and minute creatures may be carried through the air to very distant places; but we have no authentic records of organic life within the polar circle, or in either of the other two azoïc classes of the atmospheric ocean. The following synopsis of the synorganic and azoïc classes and alliances of atmospheric unity may be deemed sufficiently accurate for a general outline of this realm.

GENERAL SYNOPSIS OF THE ATMOSPHERIC REALM.

Connective Azoïc Atmospheres.	Z.	Supernal Forces.	H. *Genealogical origin and relations.*
			U. Climatic influences.
			Ω. Recuperative resources.
			O. Physiorganic forces: light, heat, magnetism, etc.
	Y.	Ingesta and Infesta.	H. *Impregnata and infesta (?)*
			U. Investa (?)
			Ω. Recent ingestions; cold air from poles; warm from tropics.
			O. Currents of renewed air in all zones, etc.
	X.	Eliminations.	H. *Recombination of the two gases.*
			U. Loss of oxygen.
			Ω. Loss of nitrogen.
			O. Loss of both gases.
	W.	Azoïc Classes of Strata.	H. *Subterranean air (?)*
			U. Polar altitudes and latitudes.
			Ω. Meteoric altitudes and latitudes.
			O. Auroral altitudes and latitudes.

Central Synorganic Zones and Longitudes.	VII.	TORRID ZONES.	H.	*Torrid longitudes.*
			U.	Inner torrid degrees.
			O.	Medial torrid degrees.
			Ω.	Outer torrid degrees.
	·7.	Inosculo-Torrid.	H.	*Inosculo-torrid longitude.*
			U.	Inner degrees of zone.
			O.	Medial degrees of zone.
			Ω.	Outer degrees of zone.
	VI.	ARDENT ZONES.	H.	*Ardent longitudes.*
			U.	Inner ardent degrees.
			O.	Medial ardent degrees.
			Ω.	Outer ardent degrees.
	·6.	Inosculo-Ardent.	H.	*Inosculo-ardent longitudes.*
			U.	Inner degrees of zone.
			O.	Medial degrees of zone.
			Ω.	Outer degrees of zone.
	V.	TROPICAL ZONES.	H.	*Tropical longitudes.*
			U.	Hyper-tropical degrees.
			O.	Medio-tropical degrees.
			Ω.	Hypo-tropical degrees.
	·5.	Subtropical Zone.	H.	*Subtropical longitudes.*
			U.	Inner degrees of zone.
			O.	Medial degrees of zone.
			Ω.	Outer degrees of zone.
External Synorganic Zones and Longitudes.	IV.	GENIAL ZONES.	H.	*Genial longitudes.*
			U.	Inner genial degrees.
			Ω.	Medial genial degrees.
			O.	Outer genial degrees.
	III.	TEMPERATE ZONES.	H.	*Temperate longitudes.*
			U.	Inner temperate degrees.
			Ω.	Medial temperate degrees.
			O.	Outer temperate degrees.
	·2.	Vario-Temperate Zones.	H.	*Vario-temperate longitudes.*
			U.	Inner degrees of zone.
			Ω.	Medial degrees of zone.
			O.	Outer degrees of zone.
	II.	VARIABLE ZONES.	H.	*Variable longitudes.*
			U.	Inner variable degrees.
			Ω.	Medial variable degrees.
			O.	Outer variable degrees.
	·1.	Frigivariable Zones.	H.	*Frigivariable longitudes.*
			U.	Inner degrees of zone.
			Ω.	Medial degrees of zone.
			O.	Outer degrees of zone.
	I.	FRIGID ZONES.	H.	*Frigid longitudes.*
			U.	Inner frigid degrees.
			Ω.	Medial frigid degrees.
			O.	Outer frigid degrees.

The articular factors of each zone-alliance of degrees of latitude and altitude are longitudinal; and these are

Pacific longitudes, austral and boreal; Europe-African longitudes, austral and boreal; Asian-Australasian longitudes; and American longitudes, austral and boreal.

PHYSICAL CHARACTERISTICS OF THE ATMOSPHERIC REALM.—In contrast with this parallel between organic and inorganic realms, we may form a physical and physiological parallel: for there are *radiatory* modes of action in all the strata of the atmosphere; *vibratory* modes of action in all winds and currents; *permutations* of state in all strata; different degrees of expansion and condensation or *complexity* of structure, in the different strata, more suitable to one federation of flora and fauna than another, more dense or more elastic in one strata than another; and, therefore, different *types* of atmosphere in different latitudes and special regions.

There are special modes of *genetic* recombination; special modes of *alimentary ingestion* and *diffusion;* special modes of general translation. "*Trade-winds, monsoons, hurricanes, cyclones*", and numerous other technical terms, denote these inosculatory modes of action; and, therefore, we need not dwell upon them further than to point out the fact of their existence.

These atmospheric phenomena require to be distinguished from mere pluvial phenomena in the study of meteorology, and the most rapid glance is sufficient to distinguish one from the other.

It is not our purpose to deal with the details of atmospheric meteorology; these will be found, as far as known and understood, in standard works on atmospheric phenomena. We give the faintest outline of all the epicosmic realms, except that of the vertebrata; and even this we do not dwell upon at any length: our business being not so much with special science as with organic method and philosophy.

THE PLUVIAL REALM.

As in the human body there are seven distinct systems and five inosculatory senses, so in the epicosmic world there are seven distinct and five inosculative realms; the latter being of an intermediate and inferior rank. The pluvial is one of these, being intermediate between the oceanic and the atmospheric realms. The subdivisions of the five senses are the same as those of the seven systems, and the natural subdivisions of the five intermediate realms are similar to those of the seven higher realms. We have, then, one main class of *aquapluvial* phenomena, and three secondary classes of *altero-pluvial* phenomena, if we may coin a word for the occasion. Floating gases, dusts, and falling meteors, are distinct classes of pluvial phenomena, very much inferior to the aquapluvial in importance; and thence we give them connective rank in this realm.

Meteorology is the special science mainly interested in the study of this part of epicosmic nature, and as our business is with general outlines and illustrations only, we refer the reader to standard works on meteorology for all details which are omitted here. A general synopsis, with a few remarks on special points, will serve the purpose of organic method, as applied to the anatomy and physiology of this inorganic realm; and that is all we need at present. Clouds and rains are the chief phenomena of the aquapluvial class in every region of the globe; and these correspond in parallel with the organic factors of an animal or a plant: that is to say, genesis, ingestion, and circulation in clouds, correspond to the same functions in organic types. Rains, rivers, reservoirs, and springs, contrast with clouds, as the relational systems of wood, bark, and pith, contrast with the inges-

tive roots and circulatory vessels in a plant. The *factors* are the same in every case, whatever be the form and structure of the parts that serve as factors in the mechanism of the realms.

In every special unit there are *limitative, oscillative, resistive, electrophoric, reproductive, assimilative,* and *circulative* systems; and these must be analytically distinguished in pluvial phenomena as in other cases.

Clouds and rains are the leading forms of the aqua-pluvial class; and these are naturally subdivided into special factors.

The action of physical forces, such as heat, electricity, magnetism, etc., in producing and regulating pluvial phenomena, hold connective rank as pluvial factors, well known to meteorologists. Dews and mists; rain, hail, and snow; rivers and springs; lakes and reservoirs of snow and ice, need no particular definitions. Evaporation, cloud formation, and cloud circulation, are also too well understood to require explanation. "Ingestive clouds" are evidently those which absorb other clouds; "digestive clouds" are those which assimilate ingested clouds; "egestive clouds" are those which discharge their contents, whatever they may be—hail, rain, or snow; gas, dust, or cinders. Clouds are generated by the distillation of aqueous vapours from all realms, and more especially from the surface of the ocean. We deem it quite legitimate, therefore, to use physiological terms in application to the quasi organic phenomena of inorganic realms.

Clouds and rains exist, with some remarkable exceptions, in every climate of the globe, and therefore we may form an organic scale of pluvial forces and phenomena, in parallel with those of an individual organism, and also a more general scale of pluvial alliances adapted to all climes. Just as we find a certain number of

systems in the human body, and a parallel number of alliances in the mammalian class of vertebrata, so we find a corresponding number of special and general factors in pluvial phenomena. The local cloud and rain factors may be thus arranged in brief:

Z. Supernal pluvial forces: heat, electricity, etc.
Y. Ingesta or contents of clouds: vapour, gas, dust, etc.
X. Connective cloud products: meteors, dusts, gases.
W. Connective clouds and rains: meteoropluvial, pulveropluvial, gaseopluvial.

VII. CIRCULATORY CLOUD FACTORS, AND PHENOMENA.
·7. Inosculatory cloud factors and phenomena.
VI. GATHERING CLOUD FACTORS AND PHENOMENA.
·6. Inosculatory commingling phenomena.
V. EVAPORATIVE FACTORS AND PHENOMENA (cloud, genesis, etc.).
·5. Inosculatory evaporative surfaces on sea and land.

IV FALLING RAINS, hail, snow, etc.
III. CUMULATIVE lakes, reservoirs, glaciers, etc.
·2. Filtering springs and sources.
II. RUNNING STREAMS AND RIVERS.
·1. Trailing fogs and mists.
I. CONDENSING SURFACE DEWS.

In all these aquapluvial phenomena we find different factors, just as in the mechanism of an animal or vegetable organism. In parallel with the vascular system, we have expanding or ascending clouds; condensing or descending clouds; and ordinary circulating clouds; to which we may add, ascending, descending, and circulating inosculatory phenomena. In parallel with the digestive system, we have ingestive, digestive, and egestive cloud phenomena, and all the inosculatory facts pertaining to these functions. In the genesis or reproductive cloud phenomena, we have evaporation, rising vapours, and cloud formation, with all the inosculatory functions pertaining to these genetic operations. In falling rains we have the different forms of rain, hail, and snow; in reservoirs we have lakes, glaciers, and Alpine snow; in rivers we have running waters, floating ice, etc. In dews we have dew, hoar frost, and literal ice. Fogs and mists are of various kinds; and so are springs and mineral or simple sources.

We need not dwell upon details to show that all these aquapluvial phenomena are strictly parallel with those of an organic mechanism, and own the same organic law of order and degrees. And as the individual organisms of animals and plants are varied in the different natural alliances, without altering the fundamental character of functional form and structure : so in the pluvial realm, the fundamental nature of cloud and rain phenomena remain the same in every clime, but they are varied in alliance with the different requirements of every diverse latitude or altitude in all the zones of the atmospheric realm. We have, then, a scale of natural alliances in the aquapluvial class, as well as a scale of functional phenomena in every locality : and these alliances run parallel with those of the atmosphere in which they occur. There are meteoropluvial, pulveropluvial, and gaseopluvial phenomena peculiar to all the zones and regions of the air : and there are aquapluvial phenomena mainly useful to the different zones and climates of the synorganic class of atmospheric phenomena. There are, in fact, torrid zone cloud and rain phenomena, differing in some respects from ardent and tropical zone pluvial phenomena ; and all these again differ from the cloud and rain phenomena of genial and temperate zones, as much, perhaps, as these differ from the pluvial phenomena of the variable and the frigid climes. The differences of meteorological phenomena, peculiar to each of these zones, may be studied in the best works of physical geography and meteorology.

We must observe, however, that the special connectives of an individual region of the synorganic class are not those of the whole realm. There are pluvial phenomena of various kinds, in the Polar, the meteoric, and auroral strata, subserving other uses than those of organic life in synorganic strata, and the general equilibrium of the pluvial and other realms. At the head of a scale of plu-

vial zones of the synorganic class, we should place connective classes of pluvial phenomena in Polar, Meteoric, and Auroral strata of the atmosphere.

SYNOPSIS OF COLLECTIVE PLUVIAL REALM.

Z.	Supernal pluvial forces : heat, light, electricity, etc.
Y.	Ingesta, etc., of clouds.
X.	Clouds and rains in azoïc regions.
W.	Connective azoïc regions of pluvial phenomena.
VII.	TORRID ZONE PLUVIAL PHENOMENA.
·7.	Subtorrid zone ,, ,,
VI.	ARDENT ZONE PLUVIAL PHENOMENA.
·6.	Subardent zone ,, ,,
V.	TROPICAL ZONE PLUVIAL PHENOMENA.
·5.	Subtropical zone ,, ,,
IV.	GENIAL CLIME PLUVIAL PHENOMENA.
III.	TEMPERATE CLIME PLUVIAL PHENOMENA.
·2.	Variotemperate zone ,, ,,
II.	VARIABLE CLIME PLUVIAL PHENOMENA.
·1.	Frigivariable zone ,, ,,
I.	FRIGID ZONE PLUVIAL PHENOMENA.

The physical characteristics of pluvial phenomena may be defined in parallel with those of organic phenomena: for there are *radiatory modes of action*, of many kinds, in clouds, such as rainbows, mock suns, mirages, lightning, etc.; *vibratory modes of action* in thunder storms, hurricanes, etc.; *permutations* of state in hail, snow, and rain; difference of *type* or *form* in water, snow, and ice; *complexity of structure* in rains charged with gas or smoke; *genetic modes of action* in different kinds of distillation and evaporation; *alimentary modes of action* in various kinds of cloud absorption and assimilation; *circulatory modes of action* in ascending, descending, and travelling clouds; difference of *electricity* in clouds oppositely charged; difference of *temperament* in clouds containing vapour, snow, or hail. In fact, all the physiological phenomena of organic bodies have corresponding phenomena in the inorganic realms; and the same methods of investigation may be naturally applied to all.

The gaseopluvial, pulveropluvial, and meteoropluvial

classes of phenomena in every locality need only be mentioned, as they are partially explained in special works; and we have nothing to add to that which is already known.

THALATTOSPHERIC OR OCEANIC REALM.

Synorganic and Azoic Seas.—In contrast with the atmosphere enveloping the globe from pole to pole, the ocean forms a second envelope, which covers some three quarters of the earth, and would cover the whole crust if the lands now raised above the level of the waters were sunk below, and other parts now sunk below were raised a little in the deepest parts. The average depth of the sea being now about four miles, and the average height of the land less than a quarter of a mile, if the latter were sunk three miles below the surface, while the average bed of the sea was raised one mile, the whole globe would be enveloped by a sea three miles in depth. We may therefore fitly call the ocean a thalattospheric realm.

We have to consider four classes of strata in the sea, with all the natural divisions of each class in zone alliances, etc. One main class of *synorganic* strata, and three secondary classes of *azoïc* strata, are contrasted in this as in all other realmic parallels.

The synorganic seas descend most probably two miles below the surface; while the lowest depths, being quite unfit for animal or vegetable life, are truly azoïc in structure and in uses. Besides these depths, there are subterranean seas which serve as feeders for vast areas of steam and gas, connected with volcanic regions, as instruments of geodynamic operations in the generation of new strata, and the wave-like perturbations of upheaval and of sub-

sidence in all the crust above and below the bed of the sea. The Polar seas of ice again, are quite distinct from all these saline seas, and form a third azoïc class of oceanic waters.

There is but little salt in the frozen seas; while there is much more salt in the deepest seas than in the superficial strata; and, as the subterranean seas are constantly distilled by heat in the volcanic regions, the steam and gases thus evolved must leave the waters more saline than even those of the deep strata not engulphed in subterranean regions. Two of the connective classes, then, are more salt than the synorganic class, while the pure ice class is not at all saline.

An individual mass of water in the synorganic strata holds numerous salts in solution, while the ice of frozen seas is formed of water unalloyed with saline matter. The chemical structure, therefore, of an individual block of Polar ice is much more simple than that of a complex mass of saline water in the other seas. These again differ in degrees of chemical complexity not only as classes, but also in their natural subdivisions of individual regions in each zone or latitude of oceanic strata. The water unalloyed is every where the same no doubt, but salts held in solution by these waters differ in proportion in the different strata of each class, and in the classes of the realm. More than thirty salts have been detected in the ocean, but no systematic plan of comparing the constituent elements of one sea with those of another, or one oceanic region with another of the same class, has been attempted, although it is well known that different families of animals and plants thrive better in one region than in another, and better at one depth of strata than another. We need not dwell, at present, on the chemical structure and the physical characteristics of oceanic waters in the secondary classes, but a cursory glance at

those of the synorganic seas, will show that such a process of investigation is now required for the due appreciation of the nature and the uses of the oceanic realm.

To analyse a single pail of water taken from any one of the different depths of what we call the zoïc strata, would not give us quite so good a view of difference in chemical constitution and physical peculiarities, as a general view of each successive depth in a given region, where animals and plants of distinct families and species inhabit particular localities more suitable to them respectively than any others. There must be something different in the chemical and physical peculiarities of all such strata to suit the different requirements of the animals and plants indigenous to them.

Oceanic Factors.—As in the special regions of the atmosphere we found the organic factors of the air to correspond with those of animal and vegetable organisms, so in the special regions of the sea we find the same parallel of *limitative, oscillative, resistive, electrophoric, reproductive, assimilative,* and *circulative* factors and phenomena. And, besides these special factors which are active in all regions, we have natural alliances of strata in the different zones and depths of the aqueous ocean, as in the different zones and climates of the atmospheric ocean. The same organic law, in fact, rules every realm, and the same organic method is applied to each.

The synorganic strata of the atmospheric ocean have been classed according to different zones of latitude and altitude in their natural connection with different federations of flora and fauna; and the same divisions may be formed in the synorganic strata of the ocean proper; for animals and plants which live and thrive in the equatorial latitudes of the sea, are not found in the Arctic latitudes, nor those of the latter in the former. We have, then, *Arctic, temperate, subtropical,* and *tropical* lati-

tudes in the ocean as well as in the air; and different expositions of latitude and longitude form exceptions in this case as in the other.

There are also translatory currents circulating in all latitudes, as well as ingestive or sinking and rising motions from one strata to another. The salts of oceanic waters are constantly decomposed by animals and plants living in the sea, and as constantly recombined by the importations of new matter. We have, then, a reproductive system, an alimentary system, and a circulatory system of oceanic waters in every region, besides the general distinctions of different zones or latitudes; and parallels may thus be formed as easily as in the atmospheric realm.

Oceanic currents are circulative factors and phenomena; aërating waves are respirative factors; great estuaries and the mouths of rivers are ingestive and assimilative factors; while the tidal flux in rivers, and the commingling of fresh with salt waters, are digestive factors. The decomposition and recomposition of sea water, by the separation and reunion of oxygen and hydrogen gases in the ocean, are genetic factors and phenomena; and, as much of this occurs wherever animal and vegetable life abound, not to mention mineral changes and recombinations, there are every where genetic factors busily at work within the ocean. The oscillations of the tides are manifestly oscillative factors; the different densities of strata are resistive factors; the various outlines of the shores and the uneven bed of the sea, which limit and give form to the ocean, are limitative factors, and certain boundaries of hot and cold strata are also limitative factors. Electrophoric factors and phenomena are known to exist in the sea, but they are not well understood. We have, then, limitative, oscillative, resistive, electrophoric, reproductive, assimilative, and circulative

factors and phenomena in every local region of the sea, as in every special region of the air, and in every special type of animal or plant in the organic realms. We have also general zones and latitudes of oceanic climates in every class of seas, as we have general alliances of animals and plants in every class of organic forms.

A table of these factors will give us a view of local marine unity; a synopsis of zone alliances, a general view of unity in this realm. The first will form a parallel with the systems of the human body; the second with the classes and alliances of an organic realm. They will serve as illustrations of organic method, and that is all we aim at in the present case. Special works on the hydrography of the sea, and the habitat of marine animals and plants, must be consulted for details.

ORGANIC OCEANIC UNITY.

Z. Supernal oceanic forces: heat, electricity, etc.
Y. Oceanic ingesta, infesta, etc.
X. Oceanic precipitations, etc.
W. Connective suspensions and solutions, etc.

VII. Aerative, Circulative, and Depurative factors and phenomena.
·7. Aerative wave-crest, foam, etc.
VI. Assimilative oceanic factors and phenomena.
·6. Ingestive and egestive oceanic factors and phenomena.
V. Reproductive oceanic factors and phenomena.
·5. Gaseo-inosculative oceanic factors and phenomena.

IV. Electrophoric oceanic factors and phenomena.
III. Resistive oceanic factors and phenomena.
·2. Vibratory oceanic factors, etc. (waves).
II. Oscillative oceanic factors (tides).
·1. Radiatory oceanic factors (transparency, etc.).
I. Limitative oceanic factors and phenomena.

All these factors and phenomena exist in every individual portion of the sea, however large or small we make that portion, for the purposes of structural and functional analysis. We need say little more of each of these organic factors, as the terms explain themselves to those who are prepared for such a study; and others must read special works for special information.

Zone Alliances.—The oceanic zones run parallel with those of atmospheric zone-alliances; but we have not the same amount of information with regard to the federations of marine fauna and flora inhabiting each latitude and altitude of the aqueous ocean, as we have of those inhabiting the different zones of the atmospheric ocean. We cannot, therefore, name the animals and plants most characteristic of each oceanic climate; but we know that the temperature of the sea decreases in descending from the surface to the greatest depths under the equator, and in extending from the central to the polar regions in both hemispheres. We may thus conclude that torrid, ardent, tropical, genial, temperate, variable, and frigid zones of oceanic waters, are found in the superficial strata, where different federations of fauna and flora find suitable conditions of organic life; and that a similar gradation may be found as we proceed from the surface to the lowest habitable depths under the equator. A general synopsis may be formed of all these zones of oceanic latitudes and altitudes; and accurate investigations will inform us which are the federations of marine fauna and flora most peculiar to each of these zone-alliances.

Distribution of Marine Fauna and Flora.—In Mrs. Somerville's *Connexion of the Physical Sciences*, she observes, that "Similar laws regulate the distribution of plants in different zones of the atmosphere and of the sea. Groups of algæ or marine plants affect particular temperatures or zones of latitude and different depths, though some few genera prevail throughout the ocean. The polar Atlantic basin to the fortieth degree of north latitude presents a well-defined vegetation. The West India seas, including the Gulf of Mexico, the eastern coast of South America, the Indian Ocean and its gulfs, the shores of New Holland, and the neighbouring islands, have each their distinct species. The Mediterranean possesses a

vegetation peculiar to itself, extending to the Black Sea; and the species of marine plants on the coast of Syria and in the port of Alexandria, differ almost entirely from those of Suez and the Red Sea. It is observed that shallow seas have a different set of plants from such as are deeper and colder; and, unlike terrestrial vegetation, the algæ are more numerous in the mean latitudes than either towards the equator or the poles. They vary also with the depth; completely different kinds affect different depths, their seeds being of such specific gravity as to remain and germinate where the parent plant grew.

"In the dark and tranquil caves of the ocean, on the shores alternately covered and deserted by the restless waves, on the lofty mountain and extended plain, in the chilly regions of the north, and in the genial warmth of the south, specific diversity is a general law of the vegetable kingdom, which cannot be accounted for by diversity of climate; and yet the similarity, though not identity, of species is such, under the same isothermal lines, that if the number of species belonging to one of the great families of plants be known in any part of the globe, the whole number of flowering or more perfect plants, and also the number of species composing the other vegetable families may be estimated with considerable accuracy.

"Various opinions have been formed on the original or primitive distribution of plants over the face of the globe; but since botanical geography has become a science, the phenomena observed have led to the conclusion that vegetable creation must have taken place in a number of distinctly different centres: as the islands and continents rose above the ocean, each of which was the original seat of a certain number of peculiar species which at first grew there, and nowhere else. Heaths are exclusively confined to the Old World; and no indigenous rose-tree has ever been seen in the New; the whole southern hemisphere

being destitute of that beautiful and fragrant plant. But this is still more confirmed by multitudes of particular plants having an entirely local and insulated existence, growing spontaneously in some particular spot and in no other place : for example, the cedar of Lebanon, which grows indigenously on that mountain, and in no other part of the world. On the other hand, as there can be no doubt that many races of plants have been extinguished, Sir John Herschel thinks it possible that these solitary instances may be the last surviving remnants of the same group universally disseminated, but in course of extinction, or that perhaps two processes may be going on at the same time :—'Some groups may be spreading from their foci, others retreating to their last holds.'

"The same laws hold in the distribution of the animal creation. Even the microscopic existences which seem to be the most widely spread, have their specific localities; and the zoophyte occupying the next lowest place in animated nature, is widely scattered through the seas of the torrid zone, each species being confined to the district and depths best suited to its wants. Molluscs, or the animals of shells, decrease in size and beauty with their distance from the equator; and not only each sea and every basin of the ocean, but each depth is inhabited by its peculiar tribe of fish. Indeed, MM. Peron and Lesueur assert that, among the many thousands of marine animals which they had examined, there is not a single animal of the southern regions which is not distinguishable by essential characters from the analogous species of the northern regions.

"Reptiles are not exempt from the general law. The saurian tribes of the four quarters of the globe differ in species; and although warm countries abound in venomous snakes, they are specifically different in different localities, and decrease both in numbers and in the viru-

lence of their poison with decrease of temperature....Each species of bird has its peculiar haunt, notwithstanding the locomotive powers of the winged tribes. The emeu is confined to Australia; the condor to the Andes and their declivities; and the bearded vulture, or semmergeyer, to the Alps. Some birds, like the common sparrow, have a wide range; but those met with in every country are few in number. Quadrupeds are distributed in the same manner wherever man has not interfered. Such as are indigenous in one country, are not the same with their congeners in another; and with the exception of some kind of bats, no mammiferous animal is indigenous in the Polynesian Archipelago, nor in any of the islands on the borders of the central part of the Pacific."

Particular federations of fauna and flora are confined, then, to particular zones of latitude and longitude in both the atmospheric and the oceanic realms; and some kinds of animals migrate from one region to another when the seasons modify the temperature of those which are respectively most genial to the migratory tribes. MIGRATIONS may, however, be from one zone to another of altitude as well as latitude, either in the sea or on dry land. In speaking of the tunny fisheries in the Mediterranean sea, M. De Quatrefages observes that "it is well known that this fish (the tunny) appears every year, in immense numbers, in the neighbourhood of Gibraltar, where they separate into two columns,—one following the shores of Africa, whilst the other makes its way along the coasts of Europe. The successive appearance of these shoals in different localities, and their inexplicable disappearance on the approach of cold weather, led for a long time to the belief that they made actual migrations similar to those of birds. In this respect the tunny resembled the herring and the mackerel, which had at all times been regarded as migratory fish; but M. Valenciennes having

confirmed by personal observation the doubts which had already been advanced in reference to this point by Lacepède and Noel de la Morinière, shewed that these pretended voyages had really no existence. Neither the tunny nor the herring leaves its native country. The fact is, however, that during winter they seek shelter from the cold at a depth to which no net can reach; and when the sun has warmed the surface of the sea, and their season of reproduction has arrived, they leave those abysses of the deep, and approach the neighbouring shores, in order to deposit their eggs in warm and shallow waters."

From this we see that migrations of altitude are just as natural as those of latitude, and both are made for similar purposes. As in the atmosphere, so in the sea, zones of latitude and altitude are both alike in adaptation to the uses of organic bodies, and particular federations and migrations of animals and plants, or vegetable seeds and fruits. We may, therefore, recognise a scale of oceanic zones as natural and complete as those of atmospheric latitudes and longitudes, using the same terms to indicate parallel degrees of distance from the poles to the equator, and from the surface to the greatest synorganic depths.

GENERAL SYNOPSIS OF OCEANIC REALM.

Z.	Supernal forces: solar and lunar attraction, light, heat, etc.
Y.	Oceanic ingesta and infesta: rains, floating ships, etc.
Z.	Connective icebergs, deep sea sediments, subterranean steam, etc.
W.	Connective seas: Polar, Deep, and Subterranean.
VII.	TORRID OCEANIC ZONES.
·7.	Inosculo-torrid oceanic regions.
VI.	ARDENT OCEANIC ZONES.
·6.	Inosculo-ardent oceanic regions.
V.	TROPICAL OCEANIC ZONES.
·5.	Inosculo-tropical oceanic regions.
IV.	GENIAL OCEANIC ZONES.
III.	TEMPERATE OCEANIC ZONES.
·2.	Variotemperate oceanic regions.
II.	VARIABLE OCEANIC ZONES.
·1.	Frigivariable oceanic regions.
I.	FRIGID OCEANIC ZONES.

LONGITUDINAL DISTINCTIONS.—Each of these zones of

latitude and depth may be naturally subdivided into four general groups of longitude, adapted to distinct federations of marine fauna and flora: and these cardinal groups of longitude are the Asian-Australasian, the Europe-African, the North and South American, the North and South Pacific. "No two marine faunas," says Mr. Darwin, "are more distinct, with hardly a fish, shell, or crab in common, than those of the eastern and western shores of South and Central America; yet these great faunas are separated only by the narrow but impassable isthmus of Panama." Many species of fish and other types of marine fauna are known to be restricted to particular zones of latitude and areas of longitude, in both the austral and boreal hemispheres; and when the sea has been as thoroughly investigated as the atmospheric regions of the earth, the federations of fauna and flora may possibly be found to be as much diversified in the different latitudes and longitudes of the one as in those of the other. The cause of this diversity in different longitudes of the same latitudes in either hemisphere, is yet unknown; but natural science is now grappling with these questions and obtaining new light every day. No one has done more to advance this branch of science than Mr. Darwin. The inner, medial, and outer degrees of latitude in each zone, bear the same relation to their respective longitudes in this, as in the atmospheric realm. It would exceed the limits of an outline to enter into any lengthened explanation of our general synopsis of the oceanic realm. Numerous details and speculations on all the questions here involved, may be found in Humboldt's *Cosmos*, and in Maury's *Hydrography of the Sea*.

Oceanic Unity.—Besides the synorganic class of oceanic strata suited to organic life, we have three azoïc classes of connective seas, the uses of which are auxilliary, and in some respects less obvious than those of the main class.

Subterranean Seas.—Some physical philosophers have first supposed there must be subterranean seas to furnish water for the subterranean action of volcanic regions, and then abandoned the hypothesis on other grounds. Nothing satisfactory, however, is yet known on any of these suppositions, while the facts denote that steam and various kinds of meteorological and geological springs are intimately connected with volcanic action. As pluvial waters penetrate the land exposed above the level of the sea, so oceanic waters must, at times, in certain places, penetrate the lands beneath the sea, either by percolation or perpetual introduction and circulation. Where percolation is habitual, the waters may be more or less deprived of salts and other matters, so that chemical theories derived from the absence of these elements, are not to be trusted without reserve. In fact, no theories are satisfactory at present; and our own requires, and will require, fuller investigation during ages yet to come.

That subterranean waters penetrate between the strata of the crust, is certain; but how they enter from the sea, and circulate, or lie comparatively still amongst the strata of the rocks, is yet unknown. Gas and steam and water do, however, penetrate between the different rocks; and even down amongst the heated regions of volcanic lava. We cannot actually see and analyse, describe and verify, the facts of all the subterranean phenomena, but we see enough of their effects upon the surface of the earth, to know that they exist, and act in divers manners, emerging from the depths in which they are habitually held in check, for purposes of use. There is a subterranean sea, then, circulating in some manner amongst the different strata of the rocks, as blood and water, air and gas, are found circulating in the human body; but the manner of ingress and egress, circulation and stagnation of these subterranean waters and gases is still but little understood.

The uses of a subterranean sea are manifest in geological phenomena; those of a polar sea are seen in hydrographical phenomena; those of the deepest azoïc seas are not so evident; but time and due investigation will, no doubt, show us what they are. The uses of the synorganic zones are manifest in the support of animal and vegetable life.

POLAR SEAS.—The freezing of the polar seas and the melting of enormous fields of ice, keep up a constant action in the polar regions to counterbalance the continuous action of the sun on equatorial seas; and these alternate actions and reactions, in addition to the oscillations of the tides, sustain perpetual motion in the sea by currents, waves, evaporation, congelation, and translation from the poles to the equator, and from the greatest depths to the exposed surface. These are conspicuous uses in the connective influence of the polar seas, and many other functions may be found no doubt for azoïc frozen seas.

DEEPEST SEAS.—The uses of the deepest seas are less conspicuous in the economy of oceanic unity, but one use may be discerned in the mechanical equilibrium of superficial changes in the surface of the crust; for, when mountain ranges rise above the level of the earth and sink again, as other portions are upheaved, it seems quite necessary that the waters of the ocean should be able to balance all these fluctuations of the land wherever they occur, and on the largest scale. The deep seas may thus co-operate with the subterranean seas in all these geological mutations, and the mutual adaptations of the geospheric and the oceanic realms in epicosmic equilibrium. Many other special uses will be found as science is developed, but this will be a work of time.

PHYSICAL CHARACTERISTICS OF THE OCEAN.—*The ends and uses* of this realm are manifest in numerous ways. Its use to animal and vegetable life is patent; and its

use to inorganic realms, in regulating and depositing sedimentary matter, is not less evident. *Radiatory modes of action* are manifest in the transparency of sea water, as well as in degrees of heat and cold, gravitation, cohesion, chemical affinity, etc.; *vibratory modes of action* are seen in waves and currents; *permutations of state,* in alternate impregnations of fresh waters with salt, and depurations of sea water by precipitations of sediment; *ingestive modes of action* are conspicuous in the perpetual absorption of fresh water from rivers, rains, and floating icebergs; *aërative modes of action* are seen in the perpetual absorption of atmospheric gases by the agitation of the waves; *reproductive modes of action* must supply the place of oceanic elements, dissolved or decomposed in the formation of various gases and minerals, mainly derived from the elements of salt and water in the sea. Various degrees of *activity and sluggishness,* in circulation and in aëration, are observed in different regions of the ocean; and various degrees or kinds of *saline constitution* are suited to different federations of fauna and flora, indigenous to different depths and latitudes of oceanic strata.

Water, steam, and gas circulating amongst different strata of rocks, may be compared with the circulation of air and sap in plants; while various kinds of sediment and gas, dissolved and circulating amongst oceanic waters, may hold the same parallel in the oceanic realm. Physical and physiological parallels exist in all the realms; though very different degrees of form and structure are peculiar to inorganic and organic bodies. We may observe, also, that volcanic and morphological functions could no more proceed without the circulation of air and water in the geospheric realm, nor oceanic functions without the circulation of sediment and gas, than the organic functions of a plant without the circulation of air and sap.

If anything analogous to *sex* in animals and plants could be implied in the genetic combinations or reproductions of salt water in the sea, it must be that water, on the one hand, is essential though insufficient; while, on the other, salt is equally essential, though insufficient when alone. Salt and water, then, are the two sexualities of oceanic genesis, in contrast with the sexualities of non-metallic and metallic elements, in the chemical genesis of each. This applies, however, to the organic factors of sea water, in a limited point of view; while the difference of Polar hemispheres in this as in all other epicosmic realms, would seem to be contrasted in Polar development, as all the animals, both male and female, indigenous to the southern hemisphere are more developed in the pelvic than in the cranial pole, while those which are indigenous to the northern hemisphere are more developed in the cranial than in the pelvic region of the body. In what peculiarities of form and structure the austral hemisphere of ocean differs from the boreal we do not know, unless it be that all the zones are more voluminous in one than in the other, as the lands above the sea are more extensive in the northern than the southern hemisphere. This and many other curious inquiries are suggested by the contrast of the Polar hemispheres in all the realms, and all the individual organisms or factors of each realm; but idle speculations on these questions would serve no useful purpose. Among the best works to consult on this subject are Keith Johnston's *Physical Geography;* the *Hydrography of the Sea,* by Lieut. Maury, of the American navy; and the *Manual* of Sir John Herschel. The following quotations from a review in *Weldon's Register* will give the reader an idea of Sir John Herschel's interesting work:

"If we leave out of the account the Sea of Aral, the Caspian Sea, and a few other comparatively insignificant

bodies of salt water, all the seas in the world are one sea; there is no ocean mass which has not communication with every other ocean mass. There is thus but one ocean, a vast expanse of salt water, in which all the continents and lesser forms of lands are set as islands.

"A glance at the map of the world will show that the direction of nearly every mass of land is meridional, or boreal austral, not only in continental masses, but in islands and peninsulas, as Great Britain, Madagascar, New Zealand, Greenland, California, Kamschatka, and Hindostan. Whence it is believed that the existing land owes its conformation to the direction of the ocean currents.

"The aggregate surface of the ocean is three times that of the land. The average depth of this vast expanse of waters is between four and five miles. Comparatively few soundings have been taken in the Pacific, but it is found that there is an unvarying proportion between the depth of the ocean and the size of its waves, and the waves of the Pacific prove that its average depth does not differ much from that of the Atlantic. The contents of the ocean are computed to measure seven hundred and seventy-eight millions of cubic miles, and to weigh one seventeen hundred and sixty-eighth part of the total weight of the earth. The ocean is six hundred and thirty times the weight of the atmosphere.

"Three and a half per cent. of its weight is saline matter, and nearly two-thirds of this is common salt: the remainder being chiefly chlorides and sulphates of magnesia, lime, and potash, with minute quantities of silica, iodides, bromides, etc. From the presence of iodine, not found in any known earth or mineral, it would seem that sea water is not indebted to the land for all its constituents; and it may be surmised from such facts as this, that science may some time discover the means of tracing

the geological history of the sea much further back than has yet been attempted. The total quantity of silver in the sea is estimated at two millions of tons; and, from what is chemically known of the soluble salts of silver, it seems reasonable to conjecture that the silver in sea water exists in a metallic form. If so, may not silver thus held in mechanical suspension have something to do with the *blue colour* so universally characteristic of salt water?

"The blue colour of the sea, as well as that of the atmosphere, has been attributed to an 'absorptive quality proper to either element.' The blue colour of the Rhone, according to Sir Humphrey Davy, might possibly be due to the presence of iodine; but nothing is yet known beyond conjecture. We are better acquainted with the causes of the red, yellow, brown, and white colours, more or less characteristic of several of the smaller seas, and which sometimes occur in the ocean, over patches hundreds of miles in extent. Ehrenberg has traced the peculiarity of colour from which the Red Sea derives its name, to the presence of vegetable matter in its waters; and, with the exception of the blue tint, all other colours are attributed either to the presence of innumerable living infusorial bodies, or to that of various organic or inorganic matters held in mechanical suspension.

"The phosphorescence of the ocean, so constantly observed in the tropics, arises from living minute and luminous organisms, some of which are of the gelatinous and some of the shell covered kinds. Their light, most visible when excited by friction, is very vivid in the spray dashed from the bows of ships and on the crests of waves, as well as in the lines following the motions of fishes on the surface.

"The saltness of the sea is not quite uniform over the globe. The greatest saltness occurs about 18° north and south of the equator, from which points internally towards

the line, and externally towards the poles, the saltness is not quite so great. Fresh water and salt water do not mix readily, and large tracts of ocean in front of the mouths of great rivers are sometimes freshened on the surface to a distance of a hundred miles or more. For the same reason, after heavy rain falls, sailors can sometimes draw up buckets full of fresh water from the surface of the ocean. The sea is also freshened in some places by submarine springs of fresh water, one of which, in the Mediterranean, causes a convexity of surface fifty feet in diameter. There are similar springs in the Pacific, among the Sandwich Islands; and on the south coast of Cuba, in the Atlantic. The waters of the Euxine, the Sea of Azoff, and the Baltic, are less salt than those of other seas, owing to a large quantity of fresh water drained into them by rivers. Evaporation is so much in excess of rain fall and river flow in the Mediterranean, that this sea would become a bed of salt in less than thirty-five centuries, were it not supplied by the current setting into it from the ocean, through the Straits of Gibraltar. No rivers empty into the Red Sea, and very little rain falls into it, so that without the currents which flow into it from the Persian gulf, it would speedily become a bed of dry salt.

"Among the more evident uses of salt in the ocean are its action as a solvent upon ice, and the reduction it effects in the freezing point of water (4° Fahrenheit). But for these two qualities in sea water, the ice of Polar regions would accumulate beyond measure, and lock up the sea to a distance beyond its present limits. The preservative quality of salt prevents the putrefaction of the immense quantities of decaying organic matter contained in the ocean, while other ingredients, such as silica and lime, serve as pabulum for its inhabitants, out of which they secrete the materials for new continents.

"As the dry land has its mountains and its valleys, precipitous cliffs, and undulating plains, so has the ocean floor its elevations and depressions in equal variety. The North Atlantic Ocean is remarkable for a deep valley, running nearly east and west for twenty-one degrees of longitude, and not greatly deviating from the latitude of the Bermudas. The depth of this valley averages five miles. Northwards, the bed of the Atlantic rises, till it forms a plateau, stretching right across from Ireland to Newfoundland, at an average depth of little more than a mile. An earthquake, which ravaged Japan in 1854, caused an immense wave to cross the Pacific to California, where it left its memento upon the self-registering tide gauges of San Diego and San Francisco. The velocity of this wave, a little more than six miles per minute, together with its known breadth of two hundred and seventeen miles, enabled Professor Bache to calculate the mean depth of the Pacific along the path it took, at nearly three miles.

"The Arctic Ocean has a depth of one thousand nine hundred fathoms in the axis of Baffin's Bay, but elsewhere has no great ascertained depth. It shelves so gradually from the Siberian Coast, that the depth is only fourteen or fifteen fathoms, at a distance of one hundred and fifty miles from the land. The Mediterranean forms an ocean chasm, reaching a depth of nearly three miles in many places.

"Temperature is much more equal in the sea than on the land. There is a depth, varying according to latitude, and subject to slight modifications from local conditions, at which the same temperature prevails over the globe from the equator to the poles. This fixed temperature is reached, under a vertical sun, at a depth of seven thousand two hundred feet, where a thermometer would indicate 39° Fahrenheit. This degree of temperature is

continued in line, north and south, tending upwards till it crops out upon the surface in latitudes 56, austral and boreal, whence it sinks again towards the poles, to a depth, in the highest accessible latitudes, of four thousand five hundred feet. The equatorial temperature of the Atlantic is about 80 degrees; that of the Pacific 84. The hottest water of considerable extent is that of the Gulf of Mexico, which attains 88 degrees. The Indian ocean, under the equator, has a temperature of 85 degrees; and twelve degrees further north, off the coast of Hindostan, reaches 86 degrees.

"Nowhere, perhaps, is the sea perfectly free from currents. These are sometimes on the surface, and sometimes very far below. In many places there are constant surface and under currents going in opposite directions. Thus icebergs have been known to drive rapidly against a surface drift; and the deep-sea lead often proves the existence of such counter currents by dragging the line in a direction contrary to that of the motion of the surface water. The Atlantic and Pacific Oceans have free communication with each other at their northern extremities through Behring's and Davis' Straits, and thus provision is made for a continuous interchange of water between the equatorial and the Polar seas, whereby the heat of the one and the cold of the other are reciprocally moderated."

Sir John Herschel ascribes ocean currents to the action of winds, which prevail in one direction over large tracts of land, and drive the waters before them. "In the northern tropics, the north-east trade winds prevail, and in the south-east tropics the south-east trade winds. These winds drive the water in south-west and north-west directions. When the currents meet, their southerly and northerly motions are mutually neutralised, while their westerly motion is increased. The two currents

then proceed together as one, till they near Cape St. Roque, a few degrees south of the equator, on the coast of South America, where they divide: one part going southward, the other and larger part, northwards.

"The equatorial current, which, being split in two off Cape St. Roque, gives rise in the north to the Gulf Stream, describes in its southern portion much such a current in the South Atlantic as the Gulf Stream in the North Atlantic, though greatly inferior to that stream as to volume, rapidity, and temperature. Nevertheless, these currents in the North and South Pacific Ocean, obedient to the same laws, though modified by the form of coast lines and other circumstances, serve to keep the sea in constant motion, and do much to mitigate the heat of the torrid and the cold of the frigid zones.

"The tides are only secondary in importance to the currents of the ocean. The influence of the moon's attraction upon the sea (were the waters spread uninterruptedly over the whole earth, and the bottom of the sea free from irregularities) would raise it about five feet at the point of greatest attraction, while the sun would raise it two feet. At neap-tides they pull in opposite directions, when the water should rise by the difference between the two attractions, that is, by three feet. These effects, however, are sometimes nearly neutralised, and sometimes much increased, by the form of the ocean bed and the shore boundaries. Where the tide-wave enters a bay, broad at the entrance and very convergent, it is heaped to a great height, as in the Houghly River, up which the 'bore' or 'sudden and violent wave' rushes with such impetuosity as to sweep everything before it. In the Bay of Fundy, where the bottom for a long way shoals upwards and the shore converges, the tide is said to attain a height of one hundred feet at times; and once, in the night time, at high water, left impaled upon

a sunken rock a vessel, whose crew found themselves, when light came, looking from a dizzing height upon waters far below.

"Waves caused by the winds differ materially from tide-waves, not only in being incomparably shorter, but from the little depth to which they agitate the water. A surface-wave forty feet in height and a quarter of a mile in breadth, only displaces the water at a depth of one thousand three hundred and twenty feet by an inch, whereas the displacement caused by the tidal-wave extends to the bottom, even in the deepest waters, where it amounts to from two thousand to three thousand feet.

"Notwithstanding the low freezing point of salt water ($28\frac{1}{2}°$ Fahr.), ice of enormous thickness is found in polar seas, that which forms the icy barrier in the antarctic seas being one thousand feet thick, stretching in an unbroken line one hundred and eighty feet high, for four hundred and fifty miles. Snow falling on salt water at 29° does not melt, but becomes consolidated as fresh water ice, which abounds in high latitudes, mingled with other fresh water ice brought down by glaciers from the land. Of the quantity of polar ice discharged into the ocean, an idea may be formed from the case of the abandoned ship *Resolute*, which drifted one thousand miles from its position in Melville's Straits, upon the drift of an ice field three hundred thousand square miles in extent. Such icebergs as have their origin in glaciers, often carry off portions of ancient soil, and some have been encountered in the north sea having upon them bones of mammoths and other extinct animals. By their transporting power, and abrading action in shallow water, these drifting icebergs produce important changes in the crust of the earth.

"About one-thirtieth of the total weight of the sea is in salt. Large continents, the interior of which are now far from the ocean, have vast deposits of mineral salts, left by

the drying up of brine-lakes, whose connexion with the ocean had been cut off by geological changes.

"The uses of salt in the ocean are now partly understood. Evaporation is continually taking place from the surface of the ocean on an enormous scale in tropical regions: this evaporation concentrates the salt water at the surface, which thus becoming heavier, sinks and has its place supplied by the less saline water from beneath. Thus the presence of salt in connexion with evaporation, ensures a constant *up and down* movement," differing from the currents of the ocean as the peristaltic movement of ingestion, digestion, and egestion in the animal economy differ from the aëration and circulation of the blood.

"Salt is necessary to the well being of marine animals, few of which can long live out of sea water. The salmon and some other fishes, which ascend our fresh-water rivers, are only partial exceptions to the rule.

"It was formerly supposed that animal life could not exist at very great depths of the sea, but Dr. Wallich states that between Capes Farewell and Rockach, bottom was found at twelve hundred and sixty fathoms; and when the sounding line was drawn up, after trailing on the ocean's bed, it brought up several star fish full of life and vigour.

"The bed of the Atlantic Ocean, at the depth of a mile and more, is covered with living infusoria, and many minute animals are known to build up coral reefs in the sea. The diatomaceæ, so small that a cubic inch is said to contain five millions, are eaten by the salpæ, which in their turn being eaten by cetaceans, furnish mediately food for the largest whales. These microscopic diatoms exist in such inconceivable numbers that their siliceous cases form by far the greater portion of the bed of the ocean, while vast fossil beds of them are found in

nearly all parts of the known world. The 'tripoli powder,' used for polishing metal, consists almost exclusively of these flint cases: and so does the Victoria barrier, a bank in the Arctic Ocean four hundred miles long by one hundred and twenty miles wide. They are also found abundantly in chalk, flint, coal, peat, and bog iron ore: they constitute in fact, an important part of the earth's crust in almost every region.

"It is believed that the diatomaceæ constitute the chief food of all the smaller molluscs and crustaceæ; and as these are the chief food of all the larger fishes, the mightiest creatures inhabiting the deep are indebted for their sustenance to these microscopic atoms. Throughout the Bay of Bengal and the Indian Ocean, and thence to the Atlantic, masses of the living organisms are seen as enormous 'yellow streaks, flakes, and tufts.' The salpæ which feed on these diatoms, exist in such quantities in some places as to render the sea of the consistence of jelly. A part of the ocean near the coast of California is called 'Vermilion Sea,' from being deeply tinged by numberless myriads of infusoria, and the ocean waters of the coast of Lima and those which surround Ceylon, have the same colour from a similar cause. Twenty thousand square miles of the Arctic Ocean are of a deep green colour and very opaque, from the presence of innumerable microscopic medusæ.

"Marine growths, almost as surprising from their vastness as the microscopic animalcules for minuteness, occupy vast regions of the sea. On the north-west coast of North America, there is a kind of sea-weed, the stem of which is no thicker than whipcord, which is more than three hundred feet long, terminating in an immense floating air vessel, shaped like a barrel, six or seven feet deep, from which proceed some fifty forked leaves, each thirty or forty feet long, radiating in fair weather, from the central

float, to a circumference nearly one hundred feet in diameter. The stem of another kind of sea-weed found on the southern coast of the same continent, is sometimes fifteen hundred feet long, ending in a mass of floating foliage occupying an area of several hundred square yards. This colossal alga grows from a depth of forty-five fathoms, and its beds form excellent natural floating break-waters."

The varieties and multitudes of marine animal and vegetable organisms are more remarkable and curious in some respects than those inhabiting the land, but less is known of the life history of oceanic species, and our space excludes details which may be found in special works.

THE RELIQUIAL REALM.

Reliquial Classes.—The vestiges of all the epicosmic realms, embedded in the earth at different periods of the history of the world, become an intermediate realm, and form a special branch of study quite as interesting as the rest. Its natural divisions are also those of the epicosmic world, since every realm leaves relics of its former states of evolution; even the vestiges of former ages may be buried in the ruins of more modern periods. There is one main class of relics, then, including the remains of all divine creations; and three secondary classes, including those of the industrial, artistic, and scientific creations of the human race. The relics of instinctual creations, such as honeycombs, birds'-nests, etc., belong to these connective classes, as the works of finite creatures in contrast with the relics of divine creations.

Reliquial Factors.—The vestiges of all the realms are the organic factors of this one; the successive periods of time and zones of sepulchral deposit are the historical

factors or alliances of the reliquial realm. The sedimentary rocks are relics of the igneous rocks, dismembered and removed in particles from their original connections; and all the inorganic realms leave traces of their former states of evolution, registered upon the face of nature, if we could but learn to read and understand them. The necrological remains of animals and plants, such as shells, bones, and beds of coal, are found in the different strata of the sedimentary rocks; with numerous kinds of secretional exuviæ, such as eggs, fruits, gums, etc. The moultings of animals and plants, such as the feathers of birds, the scales of fishes, the wool and hair of mammals, the bark and leaves of trees, and numerous other kinds of moults, leave traces which are found in all the rocks of aqueous formation; and various kinds of fossil remains, petrified or otherwise transmuted in substance, but conserving traces of organic form, constitute the main relics of past ages in the evolution of the epicosmic realms.

Geology and palæontology deal with the main class of this realm; archæology and history with the secondary classes. For all details the reader may refer to standard works on these special branches.

The following table gives a general view of the organic factors of the reliquial realm, and little need be said of the details of any class, alliance, genera, or species of historical remains.

SPECIAL FACTORS OF RELIQUIAL REALM.

Z.	Supernal Factors.	H. *Genealogical origin and history.* U. Climatic influences. Ո. Replenishing supplies of relics. O. Physical forces of relics; chemical, etc.
Y.	Preservative Factors.	H. *Impregnators of relics.* U. Investa of relics; beds of mud, etc. Ո. Recent infiltrations. O. Natural substance of relics.
X.	Derivative Factors.	H. *Imprints, forms, moulds.* U. Transmutations, petrifactions. Ո. Substitutions. O. Conservations.

W.	Connective Factors.	H.	*Religious traditions, history, etc.*
		U.	Industrial remains.
		Ω.	Artistic remains.
		O.	Scientific remains.
VII.	VERTEBRATE Relics.	H.	*Mammals.*
		U.	Birds.
		O.	Reptiles.
		Ω.	Fishes.
·7.	Articulate Relics.	H.	*Crustacea, arachnida.*
		U.	Insecta.
		O.	Myriapoda.
		Ω.	Annelata.
VI.	MOLLUSCAN Relics.	H.	*Cephalophora.*
		U.	Lamellibranchiata.
		O.	Palliobranchiata.
		Ω.	Heterobranchiata.
·6.	Radiate Relics.	H.	*Holothuria.*
		U.	Echinodermata.
		O.	Cœlenterata.
		Ω.	Protozoa.
V.	PHANEROGAMIC Remains.	H.	*Exogens.*
		U.	Perianthous endogens.
		O.	Aperianthous endogens.
		Ω.	Aquatic endogens.
·5.	Cryptogamic Remains.	H.	*Acrogenales.*
		U.	Lichenales.
		O.	Fungales.
		Ω.	Algales.
IV.	ELEMENTAL Records.	H.	*Fixed element records.*
		U.	Inorganic decomposition records.
		Ω.	Nutritional transformation records.
		O.	Necrological decomposition records.
III.	IGNEOUS ROCK Records.	H.	*Volcanic rock records.*
		U.	Metamorphic rock records.
		Ω.	Plutonic rock records.
		O.	Magnetic rock records.
·2.	Reliquial Realm Records.	H.	*Sociological dislocation records.*
		U.	Organic realm dislocations, osseous breccias, etc.
		Ω.	Mixed realm dislocation records.
		O.	Inorganic realm dislocation records.
II.	OCEANIC Records.	H.	*Synorganic class records.*
		U.	Polar ice records.
		Ω.	Deep sea records.
		O.	Subterranean sea records.
·1.	Pluvial Records.	H.	*Aquapluvial records.*
		U.	Gaseopluvial records.
		Ω.	Pulveropluvial records.
		O.	Meteoropluvial records.
I.	ATMOSPHERIC Records.	H.	*Synorganic air class records.*
		U.	Polar atmospheric records.
		Ω.	Meteoric region records.
		O.	Auroral region records.

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Vestiges of the organic realms are easily detected, and some of those of inorganic realms, such as the relics of igneous rocks contained in sedimentary strata ; but traces of the former states of atmospheric and of oceanic evolution are not so easily recognised. They must exist, however, in connection with those of other realms, and general investigation will give us the means of deciphering them in time.

When natural and artificial remains have been found, and recognised as belonging to any particular realm, class, or species, the next important thing to know is the genealogical or necrological origin and history of the relic, and the individual organism or structure to which it once belonged. This constitutes the main foundation of the special sciences of reliquial geology, palæontology, archæology, and history. Comparative anatomy and physiology are essential to the study of palæontology, and other sciences are necessary as preliminary qualifications for the study of inorganic remains, as well as for that of sociological remains.

Fossiliferous Rocks.—The study of natural remains forms a distinct class ; and, as the organic remains are imbedded in the sedimentary strata of inorganic realms, the natural history of fossiliferous rocks is mainly that of all the epicosmic realms. In John Morris's description of the earth's crust, the fossiliferous rocks and their most notable contents are thus described :

"Fossiliferous or sedimentary rocks consist of argillaceous, calcareous, or siliceous matters, forming clay, limestones, or sandstones, very variable in their structure and composition, but which have for the most part been deposited in the form of soft mud, sand, or calcareous matter, at the bottom of the sea. These rocks contain the *remains* of organised beings, by a knowledge of which the geologist is enabled to ascertain the relative position

of any series of strata. These remains, or *fossils*, are not promiscuously mingled in the different strata, but have definite relations to each other, and point out the successive periods and physical conditions under which this or that stratum was elaborated.

"Fossiliferous rocks are naturally divided into three great series, representing very distinct periods of evolution, as manifested by the general assemblage and relations of organic remains therein contained. The first or primary period is represented by the 'primary or *palæozoïc series*' of sedimentary rocks, containing remains of the most ancient forms of life; the 'secondary or mesozoïc series' of sedimentary rocks contain the remains of less ancient forms of life; the 'tertiary or cainozoïc series' of sedimentary strata, contain the remains of more recent forms of animal and vegetable life.

"These three great series are subdivided into lesser groups of strata. The primary or palæozoïc series includes the Cambrian, Silurian, Devonian, carboniferous, and Permian groups; the secondary or mesozoïc series include the triassic, oolitic, wealden, and cretaceous groups; the tertiary or cainozoïc include the eocene, miocene, pliocene, and modern groups. The four organic realms of vertebrata, mollusca, articulata, and radiata, were represented in each of the three great series, primary, secondary, and tertiary, but in very different degrees of morphological evolution.

"The palæozoïc series is marked by the presence of fishes with heterocercal (unequal lobed) tails; of mollusca belonging to the genera orthoceras, goniatites, septœna, spirifer, productus, orthis; numerous forms of crustacea called trilobites; and many genera of corals and crinoïds, as heliolites, favosites, actinocrinus, platycrinus, pentremites. The plants of this series are chiefly ferns and lycopodiaceæ.

"The mesozoïc series is mainly characterised by the numerous remains of reptilia, such as those of the *icthyosaurus* and the *plesiosaurus*; among the remains of mollusca, by those of *ammonites* and *belemnites*, and by the remains of many forms of corals and cycadciform plants.

"The cainozoïc series is distinguished by the abundant remains of mammalia; many genera and species of shells identical with those now living; and by the remains of exogenous or dicotyledonous plants."

For the progressive history of successive formations of sedimentary strata, and the successive appearance of organic remains in all these strata, we may refer the reader to Lyell's *Manual and Principles of Geology* and Professor Owen's *Palæontology*. For those who read French, the *Cours élémentaire de Paléontologie et de Géologie Stratigraphiques*, par M. Alcide d'Orbigny, will be a valuable work to consult.

We may observe, however, that geology and palæontology are not yet perfect sciences, as neither the lithological nor the fossiliferous peculiarities of any one region of the globe can be complete exponents of the successive periods in every other region. We may accept the general definitions given of evolutionary periods in Europe, as a type of those in other quarters of the globe, but the names which may be very applicable to one continent may also be very inapplicable to another. *Cambrian, Silurian, Devonian, carboniferous*, and *Permian*, are much too limited in descriptive meaning to be applicable in all cases; and the same may be said of *triassic, liassic, oolitic, cretaceous, eocene, miocene*, and *pliocene*. The successive phases of evolution may be correct in their relations to time as indicated by these lithological and other characteristics in Europe; but where very different kinds of strata and fossils denote contemporaneous suc-

cessions in other regions, these European names would be inapplicable.

The whole globe has not been yet explored, and these names, being more or less well suited for European regions, may be accepted provisionally, but time alone, or mainly, should be the basis of a scientific definition and nomenclature in geology and palæontology. It is not our business to suggest new names for special definitions in these sciences, and therefore we shall adopt the names already used; but with such reserve as theory requires in all such cases. The true names, when once given, will apply, however, just as well to our general distinctions as those in use at present, which cannot be conveniently altered yet.

In history and archæology the names are less defective; but even these may not be as accurate as time will make them. Our business is with reliquial history in all departments, divine and human; not with the special defects of definition and nomenclature, although we are obliged to make use of these to avoid the more unpleasant necessity of coining new words, which might not be well understood.

Sociological Records.—The main class of the reliquial realm consists of vestiges of every other realm; and these vestiges are the domain of geology and palæontology.

The secondary or connective classes of the reliquial realm being those containing relics of human creation, we must consult the works on archæology and history for the information we require: and as religion is the basis of all human society, the history of different revelations and religions, ancient and modern, gives us a key to the progressive creation and development of different kinds of industrial, artistic, and scientific remains. The history of Asia, Africa, Europe, America, and Australasia, contains various traditions of the origin, the growth, and

the decline of numerous societies; and all the remains of science, art, and industry, differ in accordance with the instincts of the different races, and the institutions of different religions.

"True and false" revelations are supposed to give origin to true and false societies; or to societies that prosper or decay and die away, according to the truths or the false doctrines of religion. But imperfect views of truth may lead to social and religious decline, with or without the help of falsehood and erroneous dogmas, just as inferior types of animal and vegetable life have passed away with or without the aid of disease in former ages of the world, to be succeeded by new and more perfect forms of animal and vegetable organism.

And here we may observe that, as new religious revelations are not always developed from more ancient and imperfect religions that die away and are for ever lost, so we may infer that new creations are not always, if indeed they are in any case, developed by "natural selection" from inferior types, that die away and are for ever lost. New revelations evidently bring forth new religions and societies, as new creations bring forth new and higher forms of animals and plants. And as time is necessary to diffuse new truths and multiply the converts to a new religion, so time is necessary to diffuse new types of organism, and supplant the older and less perfect forms of animal and vegetable life.

All religions are divine creations; for man cannot, without inspiration of a high or low degree, give forth a revelation and organise a prosperous society of any kind. And as heathen revelations are of various degrees of imperfection, we may conclude that they were well adapted to the different states of mental and moral evolution in the races of mankind, to whom they were vouchsafed at given places, and in different ages of the world.

All religions being perverted by man before they are subverted and superseded by Providence, are not, in their degraded state, what they were at first; and therefore we must not judge of the value and importance of a primitive revelation by the monstrous incrustations which come down to us as vestiges of former ages. Not that we deem the reason of the present age a competent judge of the kind of spiritual food that was best suited to a former age; or that truth conveyed in historic allegories and symbolic forms addressed to the imagination of an ignorant race of men, can ever be duly appreciated by rational minds which take for granted that God does not permit imaginative language and inaccurate general expressions, in a revelation addressed to people who cannot count beyond the number of their fingers, and habitually speak of countless numbers beyond ten or twelve, as thousands, myriads, and multitudes. This, however, is not a question for discussion here, as all we have to deal with is the divine origin of religion and society, as the source of human creations in science, art, and industry. Not only the religion of each race has been revealed to it in bygone ages, but the location of the race upon the surface of the globe has been assigned to it, according to its wants and the peculiar instincts of the nation. Thus art is different in every clime; industry is different; and even science bears the mark of national and ethnological origin. The religions, the sciences, the arts, and the industries of the East, are not those of the West; those of the North, are not those of the South. As Christianity, divested of all crude theology, succeeds and supersedes all other forms of religion and society, East, West, North, and South, the arts and sciences will naturally follow; but even then, one race will be developed more in one way than another; and diversity will still impress itself upon the works of art and industry in every clime, with every race of men.

In Africa, America, Australia, and the Pacific Islands, some races of mankind seem to have been left without religious inspiration, to live like animals in herds, without intelligence enough to organise societies, and educate themselves in art, science, and productive industry. In such a state, man is a mere savage or bimanal animal, and must be born again into the spiritual sphere of revelation and religion, before he can attain to moral, social, and religious rank in nature. This second birth is even necessary for men born in civilised societies before they can throw off the natural or animal humanity and become social, moral, spiritual, and religious beings. This, however, is not a question for consideration here; our present business being limited to the historical factors and phenomena of the reliquial realm; and these consist of one primary and three secondary classes of historical records in epicosmic time and space.

Epicosmic Periods.—Three periods of time—"the palæozoïc, the mesozoïc, and the caïnozoïc—are recognised by students of geology, and these are naturally subdivided into lesser periods of time; but no organic theory has yet been made to deal with the reliquial realm as an epicosmic unit of history subject to organic laws of order, number, weight, and measure, in connection with all other realms; and more especially with human history and development.

The natural zones of all reliquial deposits extend from the equator to the poles, in latitudinal directions, on the one hand; and from the surface downwards, through successive strata, on the other; until we reach the polar azoïc strata one way, and the azoïc or igneous formations, in the other. There are, then, natural zones in this realm, as in the atmospheric and the oceanic; so that an organic scale of zone-alliances may here be found as in the other inorganic realms.

Geologists do not agree in all their views of definition and distinction, with regard to fossiliferous strata, but their views are not very different from each other, and we may accept them as sufficient approximations for our present purpose. They all agree in recognising three great epochs, termed primary, secondary, and tertiary, or palæozoïc, mesozoïc, and caïnozoïc. Sir Charles Lyell places the two latter in contrast with the former, as neozoïc and palæozoïc. The subdivisions of these general distinctions are numerous and various; and after giving the particular names and definitions of other geologists, Sir Charles Lyell forms two tables, in one of which he makes twelve secondary divisions, and thirteen in the other. There is, then, nothing very definite in established nomenclature. We shall not do any violence to recognised authorities, by making our definitions and distinctions in conformity with the natural order of organic method; for the difference is very small.

Two great epochs are recognised by Lyell before the advent of humanity upon the globe; and this gives us three natural distinctions, which may be called palæozoïc, mesozoïc, and anthropozoïc. The following table shews what may be deemed the natural subdivisions of these epochs.

SYNOPTICAL TABLE OF EPICOSMIC HISTORY.

Anthropozoïc History.	Z.	Supernal sociological forces.	
	Y.	Sociological ingesta, investa, etc.	
	X.	Sociological creations.	
	W.	Anthropozoïc periods of evolution	II. Christian period. U. Mosaic period. ∩. Patriarchal period. O. Prehistoric or Adamic period.
Mesozoïc History.	VII.	Pliocene period of epicosmic evolution	H. Preadamic. U. Pleistocene. O. Pliocene. Π. Miocene.
	·7.	Eocene period of epicosmic evolution.	
	VI.	Cretaceous period of epicosmic evolution.	
	·6.	Oolitic period of epicosmic evolution.	
	V.	Liassic period of epicosmic evolution.	
	·5.	Triassic period of epicosmic evolution.	

Palæozoic History.		
	IV.	Permian period of epicosmic evolution.
	III.	Carboniferous period of epicosmic evolution.
	·2.	Devonian period of epicosmic evolution.
	II.	Silurian period of epicosmic evolution.
	·1.	Subsilurian period of epicosmic evolution.
	I.	Cambrian period of epicosmic evolution.

It would be a waste of time to discuss the preceding table, as other names and distinctions of periods might be just as good, or even better. Science will decide the question in due time. Twelve distinctions are, however, more convenient than any other number, and probably more natural. The subdivisions or groups pertaining properly to each of the twelve periods can be most accurately formed by practical geologists; and when these are formed, they may be more or less diversified in each of the four cardinal longitudes,—Asian-Australasian, Europe-African, American, and Pacific.

The anthropozoïc epoch may be subdivided into a prehistoric period, a patriarchal period, a Mosaic period, and a Christian period. The creations of human society are known by certain relics of human industry which are evidently anterior to the historic period; by others much more numerous and important, which pertain to ancient nations; and by others still much more important, known to be the products of society during the Christian period.

The supernal sociological forces mentioned in the table relate to the genealogical origin and relations of the different races of mankind; the influence of climate on the evolution of human society; the natural resources of food and clothing on which the existence and the multiplication of the races depend from year to year; and the physical and psychical forces of the human soul, on the development of which during successive generations the whole progress of human society and epicosmic culture entirely depend.

Divine Revelations and Inspirations are the natural food of man's spiritual nature, from which he gains all his

strength of wisdom and understanding in the first ages of religious and social organisation. This wisdom is gradually complemented and improved by science gained from the patient study of the book of nature, which is also a divine revelation of another kind. Man's mind is fed, then, by revelation in all ages, where the human spirit is developed; and where that is not developed he is merely a bimanal animal guided by instinct, like all other brute creatures, and little better in his natural propensities, or more refined in habit, than a monkey or a dog, unless it be that he is more refined in cruelty to other creatures. We need not dwell, however, on these questions here, as they will find a proper place in sociology and history.

Physiological Characteristics of Reliquial Realm.—The physical and physiological characteristics of an epicosmic period of evolution are similar to those of an organic or an inorganic realm or class at any period of time. The phenomena, of course, are different at different epochs; but the factors are the same as far as laws and method are concerned. There are *radiatory* modes of action in the relics of all realms at every period, *vibratory* modes of action, *permutations* of state, *complexity* of structure, differences of *form* and *uses*, to be recognised in the history of all the inorganic and organic bodies whose relics are left behind to tell the story of their former career in the world. The simple statement of the fact is all we need for this brief outline of the reliquial realm. Lyell's *Principles of Geology* treat very fully the details of all these questions, as the *Manual of Geology* deals with the question of systematic analysis. We only need refer the reader, then, to these elaborate works for information with regard to all the natural realms; and to the best works on sacred and profane history and archæology for ample knowledge on these interesting questions.

THE GEOSPHERIC REALM.

Crust of the Globe.—The external shell bears the same relation to the body of the globe as the rind of an orange bears to the internal lobes, or the epidermic layers of the skin bear to the whole bulk of the human body. This external shell is supposed to be about twenty-five miles thick by certain authorities (Humboldt's *Cosmos*, vol. v; Bohn's edition, 1858), while others estimate it to be more than twice that thickness. Whatever be the real depth of the strictly epicosmic crust, the molten lavas of volcanic strata pierce through the other rocks, and spread over portions of the visible surface, just as other strata crop out upon the surface under water and on exposed dry land.

Volcanic depths below the upper strata of hypogene and sedimentary rocks, may be compared with the soft stratum of the subcuticular layers of the epidermis on the body of an animal. All we have to deal with is the outer rind subject to secular upheavals and subsidences; and more especially with the active class of strata underlying the more solid rocks, and causing them to sink below or rise above the level of the ocean, as the uses of submersion and regeneration, or emersion and degeneration, may demand.

In the lapse of ages sedimentary rocks may possibly be changed into metamorphic rocks; these, again, become plutonic. All rocks may be melted by volcanic heat below the depths of solid strata, and return into a kind of paste analogous to that of lava in a molten state. These transformations may occur in regular succession, as periodic oscillations cause certain portions to subside, while others are upheaved above the level of the sea. There is a plan, no doubt, of motion and mutation in these strata, and a

law of structure and of uses, in the geospheric crust as in all other epicosmic realms.

General and Special Factors.—In accordance with this plan, there must be general and special factors in the geospheric realm. It is easy to distinguish one main class of geodynamic rocks, contrasted with three secondary classes of geostatic rocks of hypogene formation, *i.e.*, volcanic, metamorphic, plutonic, and magnetic rocks. Volcanic strata are evidently the most active class, while the other hypogene strata are mainly passive or geostatic. Metamorphic and plutonic rocks are recognised by all geologists; and polar strata being distinct in their magnetic qualities, may be acknowledged as a natural connective class.

If the organic plan which governs other realms be manifest in this, we shall find special factors in each region of the volcanic class, and zone alliances in parallel with those of other realms. Is there an alimentary system in volcanic regions; a circulatory system; a reproductive system; a resistive, an oscillative, a limitative, and a thermoelectric group of systems, with corresponding functions?

All these factors are beyond the reach of direct observation; but we know, from the effects produced in geological phenomena, that agents must exist where volcanic action has occurred; and there are no regions where traces of former motions and mutations are not found.

Sedimentary rocks belong to the reliquial realm; igneous rocks alone are dealt with here. The metamorphic and plutonic classes are more easily observed than the moving class of molten lavas. These are hidden from our view except where active eruptions bring them partially to bear upon the surface. We must submit, then, to the necessity of classing these geodynamic factors according to their known effects, without being able to

describe their relative positions, forms, and structures. The main factors of a limited volcanic region must be analogous to those of every other known dynamic mechanism; and if we take the human body as a type, we find the skin as a limitative system; the muscles as an oscillative system; the bones as a resistive system; the nerves as an electrophoric system; the digestive system is a great assimilative factor; the vascular system contains aërative, circulative, and depurative factors; the generative system is a reproductive factor, the uses of which are to supply the place of decaying individuals by new and vigorous generations.

All rocks are subject to mutation and decay, and therefore some kind of reproductive system must exist in the volcanic regions of the crust. We know that certain portions of the land are sometimes swallowed up by earthquakes, while others are brought upwards in the form of tuff, etc. Gas and steam, and molten lava, rising from volcanic depths, give ample proof that some kind of aërative, circulative, and depurative agencies exist within the bowels of the earth, not more than thirty miles below the surface. Sudden upheavals and subsidences of land in certain regions show that oscillatory factors exist in the volcanic depths; and though we cannot describe the solid strata which contain and limit molten masses of lava, we know that limitative and resistive masses must exist to keep these active agencies in check, and regulate their constant operation.

As far, then, as the geodynamic factors of unseen volcanic regions are concerned, we name them from their known effects, without being able to describe them in detail.

SYNOPSIS OF LOCAL GEODYNAMIC FACTORS.

Z. Supernal forces; heat, etc.
Y. Ingesta; air, water, etc.
X. Eruptive products; lava, tuff, etc.
W. Connective gases.

VII. Circulative and aërative volcanic factors.
·7. Aërative and depurative inosculators.
VI. Alimentive volcanic factors.
·6. Ingestive and egestive inosculators.
V. Reproductive volcanic factors.
·5. Reproductive inosculators.
IV. Electromagnetic volcanic factors.
III. Resistive volcanic factors.
·2. Vibratory volcanic inosculators.
II. Oscillatory volcanic factors.
·1. Radiatory volcanic inosculators.
I. Limitative volcanic factors.

The ruling forces of volcanic agency are heat, electricity, etc. The ingesta must consist of matter swallowed up by earthquakes and reduced to a molten state, to reappear in some new combination. The products of volcanic eruptions are sent forth by the agency of heat and water, gas and steam; the latter being manifestly the connective elements in all geodynamic phenomena. The special factors hidden in volcanic depths must be imagined, as they cannot be described.

We proceed from the special analysis of a single region, to the general question of zone-alliances in the main class of geodynamic rocks. Volcanic strata must underlie all others in every part of the crust; and therefore natural alliances of volcanic regions must run parallel with those of the oceanic and the atmospheric realms; the same zones of latitude pertaining equally to the three great mobile envelopes of the globe. We cannot speak of volcanic depths, because we do not know them; but zones of latitude are manifest, and these are all we need for present purposes. The names already given to the atmospheric and the oceanic zones may not be strictly applicable to volcanic zones, but they will serve to indicate locality without regard to differences of relational activity.

COLLECTIVE UNITY OF GEOSPHERIC REALM.

Z. Supernal forces of hypogen rocks; heat, etc.
Y. Differential ingesta, etc., of hypogene rocks.
X. Differential egesta from hypogene rocks.
W. Connective, plutonic, metamorphic, and magnetic rocks.

VII. Torrid zone of subterranean volcanic agency.
·7. Inoscular volcanic cones and eruptive regions.
VI. Ardent zone of subterranean volcanic agency.
·6. Inoscular volcanic cones and eruptive regions.
V. Tropical zone of subterranean volcanic agency.
·5. Inoscular volcanic cones and eruptive regions.

IV. Genial zone of subterranean volcanic agency.
III. Temperate zone of subterranean volcanic agency.
·2. Inoscular volcanic cones and eruptive regions.
II. Variable zone of subterranean volcanic agency.
·1. Inoscular volcanic cones and eruptive regions.
I. Frigid zone of subterranean volcanic agency.

For special information with regard to volcanic agency in all the latitudes and longitudes of the boreal and austral hemispheres, the reader may consult Sir Charles Lyell's *Principles of Geology*, Humboldt's *Cosmos*, Keith Johnstone's *Physical Geography*, and other standard works. A general and systematic view is all we need for the illustration of organic method as applied to inorganic realms.

The superficial crust alone belongs to the epicosmic realms; and all below a certain volcanic depth pertains to the great body of the planet. An average height of fifty miles has been computed for the atmospheric envelope; an average depth of three miles for the universal sea; some twenty miles of depth for sedimentary and solid rocks; and unknown depths below, for molten lava and volcanic agency.

Volcanic depths and oscillative agencies exist in every latitude and longitude under the bed of the ocean and the superincumbent strata of dry land, but eruptive volcanic regions are only partially distributed upon the surface, as seen in Keith Johnstone's map, exhibiting "the distribution of earthquakes and volcanos over the globe." These local volcanic regions are to the unseen geodynamic class of factors and phenomena, what the nose and mouth and other senses of the human body are to the vascular, the digestive, and other systems of the organism.

PERIODIC OSCILLATIONS.—The epicosmic crust is not

that of astronomers, who speak of a solid wall from one to four thousand miles in thickness; it is merely the uneven cuticle which clothes the cosmic body, whatever this may be, solid or liquid, porous or compact, in its external or internal portions. The vents of numerous volcanos reach down to the fiery depths of the epicosmic shell. With respect to the physical condition of the *interior of the earth,* little more is known than that the materials must be pretty uniformly arranged about the centre; and that the *density* of the entire globe is about twice the average density of the superficial crust, or five times that of water.

The rumpled surface of the land is diversified by waves of various dimensions, not exceeding some six miles in heights above and depths below the level of the sea. These are moved alternately at different places, in particular directions, by gradual subsidences and upheavals, much perhaps, as waves are formed upon the ocean, by elevations and depressions, which affect the upper strata to a certain depth below the common level. The mobility of oceanic waves is very great, and may be measured by minutes of time, while that of geological undulations is extremely slow, and only to be measured by centuries, or even thousands of centuries. Still there is unceasing motion, and this may probably affect the various strata to a depth of forty miles or more below the surface in all parts.

Sir Charles Lyell, in his *Principles of Geology,* gives several theories of earthquakes, and the wave-like motion of the crust; and although none of these may be complete, they all admit the power of heat and water, steam and gas, as agents of volcanic perturbation. There is, in fact, a kind of circulation and "actual *pulsation* engendered in the *molten matter itself,*" according to Professor Rogers, and certainly a powerful amount of active agency in subterranean steam and water. The crust of the globe is kept in slow perpetual motion by these forces,

some parts being raised six miles above the level of the sea, while others are depressed six miles below.

However slow and secular the undulatory motions and mutations of the rind may be, there is abundant evidence that many portions of existing continents have been submerged and raised again alternately more than once during the past history of the globe; and not improbably, the lands now forming the bed of the ocean have been often raised above and sunk below the waters, in alternation with the undulatory motions of the parts which now exist above the level of the sea. The portions under water may remain ten thousand years in that position, and then be raised above, by slow upheavals, to remain as long exposed to the effects of sun and air and rain, as they had previously been immersed. These waves or swells of land must necessarily be more extensive under water than above, the sea being now three times as vast in its dimensions as dry land; and very probably it may require one hundred thousand years immersion to regenerate the portions which have been exposed to the direct influence of the sun and air and rain for a quarter of that time. Millions of years, in fact, may be required in lieu of thousands, for each of these alternate permutations; for periods of time, which seem to us immense, are but small cycles in the revolutions of eternity. The undulatory motion seems to be incessant, although perceptible to us only where earthquakes and volcanic eruptions are sudden and frequent. We conceive that many parts may be gradually rising under water, while as many others may be slowly sinking lower down into the depths of ocean. However slow and gradual these oscillations of the land may be, they are no doubt controlled by laws as constant as the laws of gravitation which regulate the tidal oscillations of the sea.

Mineralogical Constitution of Rocks.—What is the

structure of an individual mineral, such as any one of those which constitute a class of rocks? there are many kinds of minerals in complex rocks, just as there are many kinds of tissue in the human body and numerous kinds of animals in a complex class; but there are some orders of constituent elements which are common to all the individual organisms of any collective group. The proximate elements of organic tissues are mostly albumen, fibrin, gluten, casein, legumin, protein; and the simple elements in each of these, are *carbon*, *oxygen*, *hydrogen*, *nitrogen*, *sulphur*, and *phosphorus*. The simple minerals of most frequent occurrence in igneous rocks, are felspar, quartz, mica, augite, hornblende; and in lesser proportions, diallage, actinolite, albite, chlorite, leucite, stilbite, olivine, schorl, steatite, talc, topaz, agate, beryl, garnet, etc.; and the chemical elements most common in these, are *silica*, *lime*, *magnesia*, *oxide of iron*, *manganese*, *fluoric acid*, etc.

In the animal organism we have one main class of tissues and three secondary classes; so in rocks we have primary and secondary constituents.

The chemical elements are much alike in nearly all the tissues of a plant of any class, although the organs differ widely from each other in form and structure: and so it is with minerals and rocks; the chemical composition is not so various in the different minerals and crystals of igneous rocks, as the proportions and combinations, forms and structures, of these several minerals in the general structure of the various classes and alliances. Felspar and hornblende, quartz, mica, etc., represent in the mineral compounds the elementary tissues of an organic body; their different combinations in a given rock may be compared with the special combinations of these tissues in a system or an apparatus. Muscular tissue and tendinous tissue, elastic and inelastic tissues, occur in many different

organs of the body; felspar and augite, quartz and mica, occur in many different kinds of rocks. As in organic bodies, so in the inorganic, we have to distinguish simple elements from proximate elements; and these again, from tissues and organs in the one case; crystals and rocks in the other.

"In granite, modern trachytes, and many porphyritic rocks the most abundant mineral is felspar associated with quartz, hornblende, and mica. In sienite and greenstone the felspar is nearly equally mixed with hornblende and augite; while in the balsaltic rocks, hornblende and augite form the main ingredients, with a small proportion of felspar.

"*Basalt* consists of augite and felspar, *greenstone* of hornblende and felspar. *Serpentine* is a massive greenish rock with diallage and much magnesia; asbestus, steatite, and native copper, are also found in this kind of rock. *Trachyte* has a base of felspar, with embedded crystals of glassy felspar: sometimes porphyritic. *Lava*, the result of modern volcanic action, is variable in its structure and composition; being allied to trachite and basalt. Obsidian, pitch-stone, and pumice, are varieties of lava. *Porphyry* is a rock with distinct crystals of felspar imbedded in a base, either granitic or homogeneous. *Syenite* consists of felspar, quartz, and hornblende. *Granite* consists of felspar, quartz, and mica, in variable proportions; the red or grey colour depending on the felspar. Tin is generally found in granite, as well as copper, bismuth, molybdena, etc. *Protogyne* is composed of felspar, quartz, and talc. *Pegmatite* is a granular mixture of felspar and quartz, with occasional mica. The fine porcelain clays used in pottery are produced by the decomposition of granite, protogyne, and pegmatite."

The Plutonic and the metamorphic rocks are much the same as the volcanic rocks in elementary composition,

just as the organic tissues, skin, bone, and muscle, are much alike in the four classes of the vertebrate realm. We do not know in what peculiarities of structure the polar magnetic class of rocks differ from the metamorphic, the Plutonic, and volcanic; but the peculiar distinction of magnetic attraction near the poles of the two hemispheres is abundantly attested. In this, as in all other realms, there are structural, physical, and connective characteristics to be analysed.

The structural characteristics of volcanic rocks relate chiefly to the different minerals of which they are composed; as far as we can observe them in regions where they have been brought from volcanic depths up to the surface. Those of the Plutonic and the metamorphic rocks are more easily observed and better known.

THE MAGNETIC CLASS of polar rocks we cannot observe directly, and therefore cannot analyse.

THE METAMORPHIC CLASS of rocks are commonly divided into *gneiss, hornblende, micaschiste, clay-slate, quartzite, chlorite, schiste*, and *metamorphic limestone. Gneiss* is composed of quartz, felspar, and mica; *hornblende-slate*, of hornblende and felspar; *mica-slate*, of mica and quartz; *chlorite-slate*, of chlorite, quartz, and sometimes felspar; *clay-slate*, chiefly mica, quartz, or talc. *Metamorphic limestone* is a granular crystalline marble.

THE PLUTONIC ROCKS are classed as *porphyritic granite, sienitic granite, talcose granite, schorly granite, eurite granitic veins, pegmatite* and *graphic granite*. The composition of these rocks is similar in many points to that of metamorphic and volcanic rocks.

VOLCANIC OR TRAP ROCKS are subdivided into numerous orders and families of mineral structure; the most general denominations being those of *basalt, trachyte, clink-stone, green-stone, grey-stone, serpentine, pitch-stone, lava, amygdaloïd, scoriæ, tuff, laterite, agglomerate*, etc.

Numerous subdivisions are formed in some of these: basalt, including *amphibolite;* and pyroxene, *dolerite, euphodite,* and *cornean* or *aphanite.* The first of these again includes *hornblende* and *actinotite;* the second, *augite, diallage,* and *hypersthene.* Other general denominations are variously subdivided by different authors; but these details are amply given in standard works on geology.

Trap-rocks and veins, however, are merely off-shoots from the subterranean volcanic strata, and may not present a complete class of geodynamic rocks and mineral combinations. It is more by their effects than by their structure and distribution that we know this class and that of polar rocks. Here, then, we have two classes little known, as we have two, or even three, in the oceanic and the atmospheric realms.

All complex rocks are composed of simple minerals, and these are numerous and various in form and structure.

There are many different degrees of combination in minerals, as well as in organic bodies; the most simple inorganic bodies being almost as much inferior to the most complex, as a simple organic cell is inferior to a perfect phœnogamic plant or tree.

Physical Characteristics of Geospheric Realm.—Are there any peculiar *radiatory* and *vibratory modes of action* in different inorganic bodies?

Various degrees of sounding vibrations and elasticity are very marked in many kinds of simple minerals; and different degrees of transparency, conductibility, magnetism, and specific gravity are not less numerous and various than those of flexibility and elasticity.

The typical *forms* of crystals have been reduced to some half dozen geometrical classes each containing numerous orders, families, and species; not to mention a host of irregular types.

The *permutations of state* in mineral bodies are not as marked as in organic bodies, but they are nevertheless incessant in both individuals and masses exposed to the vicissitudes of light and air, heat and moisture, during ages and myriads of ages in all the volcanic and oscillating regions of the world. Not to mention the allotropic state of the so-called simple bodies, such as sulphur, carbon, ozone, phosphorus, etc., the infiltrations of gas and steam and water into different strata of the earth, as well as the effects of heat and the consequent changes and transformations of matter in volcanic eruptions, earthquakes, general upheavals, and subsidences of land under and above the level of the ocean, give us numerous examples of perturbation and of permutation on the largest scale, and in continuous operation.

There is also a *genesis* of mineral bodies as well as of organic cells, although the reproductive process be not analogous in the two cases. Still, generation and degeneration, of a certain kind, are equally manifest in both the genera and classes of inorganic and organic bodies. Various degrees of *complexity of structure* are manifest in the organic realms, and though less marked in minerals than in animals and plants, the binary, ternary, quaternary, and other chemical compounds are obvious in the inorganic realms. And moreover, as one species of plant or animal holds higher *rank* than another of the same class in the order of uses to mankind, or to the world, so it is with simple minerals, one species being more useful than another to the human race, or to the epicosmic realms. The diamond ranks higher than a simple piece of carbon, and all precious stones take precedence of common minerals less rare and beautiful in their peculiarities of form and structure.

We need not dwell on the details of different alliances, orders, families, genera, and species of minerals in each of

the four classes of rocks, as these are given in the standard works of mineralogy and geology, such as the *Manual* and the *Principles of Geology*, by Sir Charles Lyell; Beudant's *Manual of Geology and Mineralogy*, and other works of merit.

Geodynamic phenomena have been recently investigated with great care by Mr. Wood, Mr. Mallet, Mr. David Milne, and other eminent observers, who have published papers on the subject. A few extracts from a review of these in Weldon's *Register*, will give an idea of the nature and extent of volcanic agency, and what is called the "philosophy of earthquakes."

"The two mighty agents which mainly effect all geological changes in the configuration and aspect of the surface of the earth are fire and water. The former is the elevating, the latter the depressing agent. Were it not for the constant action of subterranean fire, it is demonstrable that the ocean would so encroach upon the land as, in the course of ages, to submerge existing continents, leaving perhaps the peaks of a few mountain chains to dot with islands the universal faces of the waters. The compensation for the never-ceasing abrasion of coast-lines by the ocean which intestine fire gives, is far from being confined to volcanic action, as commonly understood. The upheaval due to the eruption of lavas from the craters of volcanos are quite insignificant compared with the silent, slow action continually raising the level of whole continents. It has been proved that Scotland has been gradually rising for many centuries at a rate of several inches per century; and it is certain that the site of Glasgow was swept by the ocean waves, at a time almost within the historic period. The low plains of Belgium, Holland, and an immense low tract of Northern Siberia, have been reclaimed from the sea almost as recently, by subterranean agency.

"The upheaval of continents does not take place equally over the area elevated. One part may rise while another remains stationary or actually sinks: for subsidence occurs on an enormous scale from igneous action, as well as upheaval, although the latter may be much in excess of the former. There are centres of subterranean activity, and upheaval occurs in directions *radiating* from these centres. In a paper contributed to the *Philosophical Magazine*, Mr. Wood shows that, during the immense period from the formation of the secondary and early tertiary strata, to the present time, the upheaval produced by subterranean fire has been mainly confined to certain axes. One of these principal axes is in the direction south south-east, in the southern hemisphere, and is prolonged into the northern hemisphere where the direction is north north-west. This axis coincides with the chain of the rocky mountains in North America. The next axis is in the direction south by east and north by west, and includes the systems of England and Portugal. Another axis is nearly north and south, and includes the chain of the Andes. A fourth axis is south by west and north by east, including Eastern Australia, where there are very high mountains of volcanic origin. The fifth and last great axis makes a large angle with the others, being south-west and north-east, including the chain of the Alleghanies. It is a singular coincidence that the principal peninsulas and islands of the world take a meridional direction, and that the configuration of the continents accords with that general direction.

"Mr. Mallet began, a few years since, in England, to collect and systematise all the accounts of the phenomena of earthquakes which he could discover (see *Reports of the British Association for the Advancement of Science*, 1850, 1851, 1854, 1858); and M. Perrey, of Dijon, in France, has published similar accounts up to the year

1850. These documents range over a period of three thousand five hundred and fifty-six years.

"The area of a great earthquake may be described as a circle having a radius of six hundred miles: the area of a small earthquake may be a circle whose radius is not more than twenty miles. The kinds of disturbance caused by earthquakes, are in conformity with the elastic or inelastic character of the superficial crust. Inelastic rocks are cracked; surface rocks are broken or overturned. Buildings of all dimensions are thrown down; rivers have their courses changed, or are swallowed up in open fissures. Jets of water or gas may arise from newly formed crevices. The waters of the sea may rush in upon the land, greatly above their ordinary level, or withdraw beyond the usual low-water mark.

"The frequency of earthquakes may be estimated from the records accumulated by M. Perrey and Mr. Mallet. These show that while only 787 earthquakes are mentioned from the earliest periods to those of the seventeenth century, and only 2804 in the three succeeding centuries, no less than 3240 are recorded during the half century concluding in 1850. As there are many tracts still unexplored, all the earthquakes happening in this period have not been recorded. We are thus warranted in saying, that on an average, more than sixty earthquakes have occurred in every year. About one in every eight months has been a great earthquake.

"Earthquakes are periodical, and recur at something approaching to comparable intervals. Great earthquakes appear to have happened for some centuries, at intervals of about one hundred years; and groups of several important convulsions occur at intervals of fifty years. The middle and the latter part of the sixteenth century were marked by numerous and important earthquakes, many of them very severe, in China, Europe, and the Atlantic.

In the basin of the Mediterranean, there were disastrous earthquakes in the middle of the seventeenth century. The great Jamaica earthquake, and others of considerable magnitude, occurred near the latter end of the same century.

"Judging from existing records, the first, fifth, ninth, twelfth, and eighteenth centuries of the Christian era, have been the periods when the disastrous effects of earthquakes have been greatest upon the human race in civilised countries; while the first and second A.C., and the third, seventh, tenth, and fourteenth B.C. have been periods of comparative quietude."

Volcanic mouths are the points where subterranean phenomena are manifested locally at the surface, and from these points, their continuous agency below is traced by very extensive perturbations. "The range of the Andes, from Chili to the North of Mexico, probably from Cape Horn to Behring Straits," says Mrs. Somerville, "is one vast district of igneous action, including the Carribean and West Indian Islands, on the one hand; and stretching quite across the Pacific Ocean, through the Polynesian Archipelago, the New Hebrides, the Georgian and Friendly Islands, on the other. Another chain begins with the Aleutian Islands, extends to Kamtschatka, and from thence passes through the Kurile, Japanese, and Philippine Islands to the Moluccas, whence it spreads with terrific violence through the Indian Archipelago, even to the Bay of Bengal. Volcanic action may again be followed from the entrance of the Persian Gulf to Madagascar, Bourbon, the Canaries, and Azores. Thence a continuous igneous region extends through about 1000 geographical miles to the Caspian Sea, including the Mediterranean, and extending north and south between the thirty-fifth and fortieth parallels of latitude; and in Central Asia a volcanic region occupies 2500 square geographical miles.

The volcanic fires are developed in Iceland in tremendous force; and the antarctic land discovered by Sir James Ross is an igneous formation of the boldest structure, where a volcano in high activity rises 12,000 feet above the perpetual ice of these deserts, and within 19½° of the south pole. Throughout this vast portion of the world, the subterraneous fire is often intensely active, producing such violent earthquakes and eruptions that their effects accumulated during millions of years, may account for many of the great geological changes of igneous origin that have already taken place in the earth, and may occasion others not less remarkable, should time, that essential element in the vicissitudes of the globe, be granted, and their energy last.

"Sir Charles Lyell estimates that on an average twenty eruptions take place annually in different parts of the world, and many must occur, or have happened, even on the most extensive and awful scale, among people equally incapable of estimating their effects and of recording them. We should never have known the extent of the fearful eruption which took place in the Island of Sumbawa, in 1815, but for the accident of Sir Stamford Raffles having been Governor of Java at the time. It began on the 5th of April, and did not entirely cease till July. The ground was shaken through an area of 1000 miles in circumference; the tremors were felt in Java, the Moluccas, a great part of Celebes, Sumatra, and Borneo. The detonations were heard in Sumatra at a distance of 970 geographical miles in a straight line; and at Ternate, 720 miles in the opposite direction. The most dreadful whirlwinds carried men and cattle into the air; and with the exception of twenty-six persons, the whole population of the island perished, to the amount of 12,000. Ashes were carried 300 miles to Java, in such quantities, that the darkness during the day was more profound than

ever had been witnessed in the most obscure night. The face of the country was changed by the streams of lava, and by the upheaving and sinking of the soil. The town of Tomboro was submerged, and water stood to the depth of eighteen feet in places which had been dry land.

"Many volcanos, supposed to be extinct, have all at once burst out with inconceivable violence. Witness Vesuvius, on historical record; and the volcano in the Island of St. Vincent in our own days, whose crater was lined with large trees and which had not been active in the memory of man.

"The shell of volcanic fire that girds the globe at a small depth below our feet has been attributed to different causes. . . . Some conceive it to be superficial and due to chemical action in strata at no very great depth when compared with the size of the globe. The more so, as matter on a most extensive scale is passing from old into new combinations, which if rapidly effected, are capable of producing the most intense heat. According to others, electricity which is so universally diffused in all its forms through the earth, if not the immediate cause of the volcanic phenomena, at least determines the chemical affinities that produce them."

Sir John Herschel, in a letter to Sir Charles Lyell, states his views on the subject, thus :—" Supposing that the globe is merely a solid crust resting upon fluid or semi-fluid matter, whether extending to the centre or not, the transfer of pressure from one part of its surface to another by the degradation of existing continents and the formation of new ones, would be sufficient to subvert the equilibrium of heat in the interior, and occasion volcanic eruptions. For since the internal heat of the earth is transmitted outwards by radiation, an accession of new matter on any part of the surface, like an addition of clothing, by keeping it in, would raise the temperature of

the strata below, and in the course of ages would even reduce those at a great depth to a state of fusion. Some of the substances might be converted into gases; and should the accumulation of new matter take place at the bottom of the sea, as is generally the case, this lava would be mixed with water in a state of ignition, in consequence of the enormous pressure of the ocean and of the newly superimposed matter, which would prevent it from expanding into steam. The greatest accumulation of local pressure is in the central area of the deep sea, while the greatest local relief takes place along the abraded coast-lines. Here, then, should occur the chief volcanic vents." As the crust of the earth is much weaker on the coasts than elsewhere, it is more easily ruptured; and, as Mr. Babbage observes, immense rents might be produced there by its contraction in cooling down after being deprived of a portion of its original thickness. The pressure at the bottom of the ocean would force a column of lava mixed with ignited water and gas to rise through an opening thus formed, and, says Sir John Herschel, "when the column attains such a height that the ignited water can become steam, the joint specific gravity of the column is suddenly diminished, and up comes a jet of mixed steam and lava, till so much has escaped that the matter deposited at the bottom of the ocean takes a fresh bearing when the evacuation ceases and the crack becomes sealed up. . . .

"The numerous vents for the internal heat formed by volcanos, hot springs, and the emission of steam, so frequent in volcanic regions, no doubt maintain the tranquillity of the interior fluid mass, which seems to be perfectly inert, unless when put in motion by unequal pressure."

ELEMENTAL REALM.

SIMPLE AND COMPLEX ELEMENTS.—"Elements" are the physical matrix or substratum of other realms; for they underlie the simplest constituent cells or molecules of every lowest complex individuality.

The integral and indivisible unit of the vertebrate realm is an animal, and the lowest unit of organic structure is a cell formed of a so-called structureless tissue. The integral unit of other organic realms, is also an individual animal or plant, and the lowest element of structure an organic cell formed of "structureless" tissue. The elemental realm, properly defined, consists of all the elemental substances from which the complex units of structure are derived.

The lowest unit of "structureless" organic tissue is not indivisible by chemical analysis, but the lowest units of inorganic matter are indivisible by our present methods of analysis.

Professor Fownes tells us that all inorganic compounds are of a binary character, consisting of substances united by two; while organic substances are united by threes, or by fours, as hydrogen, oxygen, and carbon; or oxygen, hydrogen, carbon, and nitrogen. Crystalised alum, a compound inorganic body, is composed of alum and water. The water is itself composed of hydrogen and oxygen. The alum is composed of sulphate of alumina and sulphate of potash. These are again composed of alumina, with sulphuric acid, and potash with sulphuric acid. The whole mineral consists of aluminium + oxygen, sulphur + oxygen, potassium + oxygen, and sulphur + oxygen.

The comparative anatomy, physiology, histology, and embryology of an organic unit, lead us down from the

individual oaganism to a simple cell, and no further; those of an inorganic unit, lead us down from the individual body to a simple element, and no further. There are simple cells, however, in the cryptogamic realm, which rank as individual organisms; and there are simple metals which rank as individuals in the elemental realm. An organic cell may be either the lowest individuality of an individual organism; or the lowest organism of an organic realm; and a metallic element may be either the lowest constituent of an individual mineral; or the lowest unit of an inorganic realm. The vinegar cell-plant is an individual member of the cryptogamic realm, although a cell of tissue in the human body is not an individual member of the vertebrate realm; the smallest particle of gold is an individual member of the elemental realm, although the basic or metallic element of a complex mineral is not necessarily an individual member of the geospheric realm. A simple parallel will make this plain.

DEGREES OF INDIVIDUALITY IN ORGANIC UNITS.

An individual organism of the vertebrate realm.
An individual tissue of an animal body.
An individual cell of an animal tissue.

A local region of the geospheric realm.
An individual stratum of a local region.
An individual mineral of a special stratum.

A complex elemental unit of the elemental realm.
A proximate element of a complex elemental unit.
An ultimate element of a proximate element.

Complex Elemental Units.—Proteïne compounds are the most complex units of the elemental realm; eggs and seeds, blood and milk, the most definite forms of proteïne substance. The homogeneous matter of an egg is the elemental substratum of an organism. From this structureless unit are derived the whole of the organic factors of a living body. We may take the egg, then, as a perfect type of elemental complex unity, just as we

take the human body as a perfect type of individual complex unity. Anatomy gives us seven factors, with inosculators and connectives in the body; histology deals with the simple tissues of the organism; physiology, with the functions of the different factors; and embryology, with the morphological evolution of the organism. Elemental anatomy deals with the most obvious constituents of an egg; elemental histology deals with the simple distinctions of air, water, and proteïne compounds or proximate elements in the egg; and chemical analysis deals with the simple elements of oxygen, carbon, hydrogen, nitrogen, etc., found in the proteïne compounds.

The yolk, the white, the pellicles, and the shell, are the principal factors of the elemental unit, the first including all the main factors, while the others are connectives. We cannot distinguish seven alliances of elemental factors in the yolk of an egg, but we know, that with connectives, it contains the substratum of a cutaneous, a muscular, an osseous, a nervous, a genetic, an alimentary, and a vascular unity of systems in the body of the chick. The same may be said of the seeds of plants. Eggs and seeds, then, are the primary elemental substrata of organic realms; milk, blood, and vegetable proteïne compounds are the natural equivalents of eggs and seeds during the future growth and decline of animal and vegetable organisms.

It is not, perhaps, so easy to define the elemental substrata of the inorganic realms. What complex elemental units give origin to the atmospheric, oceanic, geospheric, pluvial, reliquial, and elemental integers of structure, and regenerate them through successive ages of existence? The eggs and seeds of organic units are excretions of living organisms; and the elemental substrata of inorganic units are derived from the dissolving particles of inorganic bodies. Artificial dissolutions give us the elemental substratum for artificial compounds; and natural solutions, the substratum for natural recombinations.

The elemental units of substrata in all realms may be as diverse in complexity of structure as the organic units of the realms; and here we find a vast difference between the complex organism of a vertebrate animal and the simple unit of a cryptogamic cell-plant. Anatomical and histological analysis meet in the simple structure of such an organism ; and possibly, the complex and the simple elemental unit may be equal in the primary substratum of many inorganic bodies. Free elemental substances are the natural substrata of fixed elemental compounds.

In the collective elemental realm, our first distinction is that of a fixed class of elements already combined in epicosmic realms, from those which are in a state of dissolution and isolation. The latter we divide into three distinct classes, in contrast with the one great class of elemental phenomena. *Organic* chemistry, *inorganic* chemistry, and *simple* metallurgy, form artificial classes of facts in the human laboratory, very much inferior to the primary class of epicosmic chemistry in the Divine laboratory. It is important to know something of the combinations and proportions, mutual relations and mutations of the elements in all the epicosmic realms, as a measure of distinction in the artificial isolations and association of these elements.

Elemental Factors and Phenomena.—It is not easy to find the organic factors of a cryptogamic cell-plant, although we know that limitative, oscillative, resistive, electrophoric, genetic, assimilative, and circulative factors and functions exist in it. It is still more difficult to discern limitative, oscillative, resistive, electrophoric, genetic, ingestive, and circulative factors and phenomena in the constitution of an egg, as a complex elemental unit. While the egg is being formed in the ovary, we may discern factors and functions analogous to these, which become inactive when the egg is laid. There is a law, however,

of formation and of dissolution, and factors must exist to carry out this law of order in the perpetual renewal and decay of complex elemental units.

Proximate Elements.—In a grain of wheat, which is a complex elemental unit, the "proximate elements" are said to be "gum, sugar, starch, lignine, albumen, fibrine, caseïne, gluten, fat, and ashes." The "ultimate elements" of these are, carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, calcium, magnesium, silicon. The proximate elements of organic bodies in general are, "albumen, fibrine, gluten, caseïne, legumin, and proteïn." The relative proportions of ultimate elements in each of these, are given in the following table.

	Albumen.	*Fibrin.*	*Gluten.*	*Casein.*	*Legumin.*	*Proteïn.*
Carbon .	548	546	552	550	541	550
Oxygen .	212	220	218	217	226	219
Nitrogen .	149	157	151	158	158	160
Hydrogen .	71	70	72	71	71	71
Sulphur .	7	4	4	4	4	—
Phosphorus	3	3	3	—	—	—
	1000	1000	1000	1000	1000	1000

These approximations include the most prominent elements, and these only, for traces may be found of numerous simple elements in every organic body: not, perhaps, in one class of tissues alone, but in all the classes of each realm. It is not the elements themselves that differ, but the peculiar states of molecular combination in each class of tissues, animal or vegetable. Just as in the different types of individual form, it is not so much the general distinctions of tissues and systems, vascular, digestive, generative, nervous, muscular, and cutaneous, that differ in each type, as the peculiar structure and development of these particular tissues and systems in each organism.

Allotropism and Isomerism.—All the realms of the epicosm, roundly speaking, are composed of the same elementary matter, variously combined in chemical, phy-

sical, and mechanical arrangement: the differences of proportion and allotropic morphology being manifested mainly in one particular direction in one realm, and mostly in a different direction in another. There are isomeric forms of structure, and various molecular arrangements in chemical compounds; allotrophic forms of structure in simple elements; and similar connective elements in every realm.

ULTIMATE ELEMENTS, BASIC AND CONNECTIVE.—In the *atmospheric realm*, nitrogen is the main element, and oxygen the connective or non-metallic element; the proportions being about 78 per cent. or four-fifths of one, and 22 per cent, or little more than one-fifth of the other. Divers other elements are either unknown or never mentioned as constituents of this realm, although "the spectrum analysis has led to the discovery of three volatile metals in the air, which had previously escaped observation." In the pluvial realm, aqueous vapour is the main component, and various gases hold a secondary rank. In water, hydrogen is the main element and oxygen the connective: the one being twice as much in volume as the other, although but one-eighth in comparative mass or weight. The various constituents of the secondary classes in this realm (the gaseopluvial, pulveropluvial, and meteoropluvial), may possibly be much more complex than is now supposed. Water, as such, apart from all its soluble contents, belongs mainly to the oceanic realm. The alkaline elements of sodium, potassium, lithium, etc., claim the first places as basic elements of marine salt, and their special connective elements are those of the halogene order: namely, chlorine, bromine, iodine, and fluorine. These are the most characteristic elements of the oceanic realm; which probably contains some traces if not large masses of all the elements of epicosmic matter.

It is computed that about one-thirtieth part of the whole

sea is composed of salt or chloride of sodium alone; and thirty-one different elements have been recognised in sea-water: namely, oxygen, hydrogen, nitrogen, carbon, chlorine, bromine, iodine, fluorine, sulphur, phosphorus, silicon, boron, silver, copper, lead, zinc, cobalt, nickel, iron, manganese, aluminium, magnesium, sodium, potassium, lithium, calcium, barium, strontium, cadmium, rubidium, and arsenic. Other elements may exist in the sea, but not in quantities sufficient to be easily detected. The deepest waters of the ocean may possibly contain numerous elementary bodies not yet met with in the upper strata. The leading elements of the pluvial realm are common to the atmospheric and the oceanic realms.

The reliquial realm contains remains of all the other realms, in their metamorphic evolution from primæval origins up to the present time; but many of these traces may be still unknown to us, or undeciphered in their historical bearings. This prevents us from enumerating all the elements combined in relics of past ages, but a cursory glance at the numerous fossils of organic realms, shows that *calcium* and the cognate order of basic elements of what are called the "alkaline earths", with their usual connectives, carbon, silicon, phosphorus, and sulphur, form the leading characteristics of animal remains; while carbon is most abundantly stored up in the coal-beds and other relics of vegetable structure in primæval ages. Whatever be the number and proportions of other elements peculiar to by-gone phases of epicosmic evolution, there can be no doubt that these alkaline earths and thei connective elements are predominant in the conservation of relics or extinct organic forms.

The geospheric realm contains all the known elements of epicosmic matter; but here again, we may observe that some are more prevalent in mass than others; and those which are the most predominant, are what are called "ter-

riginous elements", with their natural connectives. Aluminium and its congeners are the most characteristic basic elements of this realm, and silicon, boron, sulphur, oxygen, phosphorus, etc,. their commonest connectives. Silicon, however, may perhaps be deemed the characteristic element of this realm, as silica is computed to be nearly one-half of the solid crust of the globe. The elemental realm properly so called, necessarily contains all the elements of epicosmic matter, but some are more characteristic than others of an independent physical state of structure and function ; these are what are called the "noble metals", which are generally most useful in the uncombined state, while other elements are commonly found in chemical combination. The simple elements are perhaps equally important in a general sense, but not in special uses. The noble metals, gold, silver, copper, tin, lead, platinum, etc., are most useful to man, as simple elements or alloys, for mechanical, physical, telegraphic, and ornamental purposes, while other elements are more important in chemical combination than in physical isolation.

All the simple elements exist, then, in some of the inorganic spheres, of epicosmic nature; and not improbably some traces of them all may really exist in each of the organic realms; though some, of course, much more abundantly than others. It is also manifest that the same elements are very differently combined in different organic bodies. The carbon of woody fibre is very different in the molecular structure of the two vegetable realms, and still more different in the animal tissues of the four zoological realms : and yet nearly all the leading elements exist in both the animal and vegetable tissues.

Elemental Combinations in Different Bodies.—Quantity alone, of a particular form of matter, is not the true criterion of comparison in different types of organism.

The great mass (three-fourths) of the human body consists of water, and only one-fourth part consists of some eighteen or twenty simple elements, in addition to the two contained in water. "Organised bodies in general", it is said, "are capable of being resolved, by chemical analysis, into the inorganic simple elements; but the list of substances obtained from this source being only about eighteen, is small in comparison with those found in the inorganic world. Carbon, oxygen, hydrogen, and nitrogen, are considered essential. Two, at least, of these will be found in every inorganic compound. The other simple substances are found in smaller quantities, and being less extensively diffused, may be called the incidental or non-essential elements of organic bodies. These are sulphur, phosphorus, chlorine, sodium, calcium, potassium, magnesium, silicon, aluminium, iron, manganese, bromine, iodine, fluorine; the two latter being mostly obtained from marine plants and animals."

We can hardly admit that what has been already done in this department is at all exhaustive of the subject. Gerhardt in France, and Cannizzaro in Sicily, have already done much for the improvement of chemical science; and more may be expected from future investigations. According to the observations made by chemists, "chlorine does not exist free in organic nature, but only in combination with hydrogen or with metallic bases. The chloride of sodium, or common salt, is a constituent of the animal fluids, and in certain classes of animals must be regarded as essential to life, because it is the source of muriatic acid, the presence of which is one of the conditions of their digestion.

"*Iodine* exists in sponges, and has been detected in the oyster and other marine molluscs. *Bromine* has been found in marine plants, and in one of the testaceous molluscs, the janthina violacea. *Fluorine* exists, combined

with lime, in the bones and teeth of animals. It has been found also in the vegetable kingdom to a sufficient extent to account for its existence in the animal kingdom. *Sulphur* is particularly found in some orders of plants, as the cruciferous family and the lichens. In cruciferous plants, such as the cole-worts, the presence of sulphur is indicated by the smell of sulphuretted hydrogen given off during their decomposition. *Phosphorus* hardly exists free in any part of nature. The salts formed by its acid combinations with oxygen, are widely diffused in the three kingdoms, and appear to have important offices assigned to them in the economy of organic life. In the animal kingdom, phosphates make a prominent figure among its saline constituents. It is supposed, even that phosphorus exists in the uncombined state in the albumen and fibrine of animal bodies; and that the human body contains several pounds of phosphorus. The phosphates, and particularly the phosphates of lime, are the chief hard materials of the bones in vertebrate animals; the carbonate of lime being in very inferior proportion. In the shells of molluscs there is little or no phosphate, the hard substance being almost entirely composed of carbonate of lime; but in crustaceous animals, the hard cases of crabs, lobsters, and cray-fish, there is both phosphate of lime and carbonate of lime, though more of the carbonate than of the phosphate. In the higher types of radiata, phosphates are found generally throughout the fluids and soft parts, as well as in the external skeleton. In the lower types of radiata, the red coral yields a little phosphate of lime; while the madrepore consists entirely of carbonate of lime without a trace of phosphate.

"*Silicon*, in silicic acid or silica, is found in small proportions, throughout the organised kingdoms of nature. In the animal kingdom it is found chiefly in the bones and in the urine. In the vegetable kingdom it performs

the office of imparting strength to the stem, as in grasses, to enable them to support the weight of the grain. In the stem of the equisctaceæ or horsetails, silica is seen disposed in a crystalline arrangement. The ashes of trees and herbaceous plants growing elsewhere than on the sea-shore, contain the carbonate of potassa, thus proving the existence of *potassium* as an element widely diffused throughout the vegetable kingdom. Salts of potassa exist in some of the fluids of the human body, as in the blood, the milk, and the urine. The same salts are abundant in the urine of herbivorous animals. Soda is more particularly the alkali of the animal kingdom. Besides the chloride of *sodium*, the sulphate of soda, phosphate of soda, and various combinations of soda with the organic acids, are met with in organic tissues and fluids. Lime, or the oxide of *calcium*, exists widely diffused in organic nature. In the vegetable kingdom, the salts of lime are everywhere distributed in minute proportions, while they are sometimes abundantly diffused in the animal kingdom. Magnesia, or the oxide of *magnesium*, exists more sparingly than lime in the organic realms. Phosphate of magnesia is found in the ashes of wheat, rye, beans, and peas. It also occurs in the blood and bones of animals. *Iron* appears to be a useful element of organic nature. The oxide of iron, combined with phosphoric acid, is found in wheat, rye, and peas. It is also found in the ashes of different kinds of wood. In the animal kingdom it is a universal constituent of the blood. *Manganese* is found in various kinds of wood, and also in the human hair." (Faraday.)

If we compare the whole globe, as a cosmic individual, with the human body as an epicosmic individual, the crust of the globe may be placed in parallel with the epidermic tissues of the animal; and the organic realms may be contrasted with the inorganic realms, as the infesta

and the investa of the human body may be contrasted with the protective cuticle and cutaneous secretions.

The infesta of the higher epicosmic bodies belong mainly to the lowest types of the inferior articulata, radiata, and cryptogamia. Those of the cosmic body belong to the whole mass of the six organic realms. The natural clothing or investa of the animal body is formed of epidermic tissue and cutaneous secretions, such as hair, pigment, sebaceous oil, perspiratory water, and gaseous exhalations. The natural envelopes of the globe are composed of a solid crust of earth, a liquid sphere of water, and a gaseous envelope of air.

The epizoïc tissues and secretions do not contain all the simple elements which are found in epicosmic organisms; and, possibly, the epicosmic realms of our planet may not exhibit all the simple elements contained in the terrestrial globe; but that is not a question for immediate investigation, as we are only dealing with epicosmic nature. Let us see, then, which are the leading elements in each of these realms, and which are connective only, or common to them all.

	Fixed Realms.	*Chief Basic Elements.*	*Chief Connective Elements.*
VII.	Vertebrata	Carbon	Oxygen.
·7.	Articulata	Carbon	Oxygen.
VI.	Mollusca	Carbon	Oxygen.
·6.	Radiata	Carbon	Oxygen.
V.	Phanerogamia	Carbon	Oxygen.
·5.	Cryptogamia	Carbon	Oxygen.
IV.	Elemental	Iron	Oxygen.
III.	Geospheric	Silicium	Oxygen.
·2.	Reliquial	Alcaline metals	Oxygen.
II.	Oceanic	Hydrogen	Oxygen.
·1.	Pluvial	Carbon	Oxygen.
I.	Atmospheric	Nitrogen	Oxygen.

Here we see that oxygen is the most universal connective element in epicosmic realms; that carbon is the basic element of all organic bodies; that nitrogen is the basic element of atmospheric air; and hydrogen, of water; that

silicium is the most voluminous basic element of solid earth, as flint is the most abundant mineral in the geospheric realm. Iron is probably the most abundant of the simple metals; and, as aqueous vapour is the most abundant constituent of the pluvial realm, and ammonia is formed of hydrogen and nitrogen combined, carbonic acid gas is the most distinct and characteristic constituent, and this pluvial gas is composed of carbon and oxygen. Alkaline earths are most common in fossil remains, and these are composed of alkaline metals, silicon, and oxygen.

Basic, Connective, and Amphigenic Elements.—Some of the elements here classed as basic, such as carbon, silicon, hydrogen, and nitrogen, are classed as non-metallic elements by chemists, and contrasted with metallic elements; but this is a vexed question amongst them; for Gerhard places hydrogen with metals, and arsenic with nitrogen and phosphorus, as non-metallic elements. There are some elements, then, which act as bases only; some as connective or epibasic only; and some as amphigenic, combining easily with either basic or connective elements. The amphigenic elements, however, are mainly basic in their natural combinations, since carbon is principally found with oxygen in the organic realms; silicon with oxygen in the great rocks of the earth; hydrogen with oxygen in the ocean; and nitrogen with oxygen in the atmosphere. It is only in secondary combinations that these amphigenic elements perform the office of connectives, in union with metals. There are, however, several kinds of connective elements never found as bases in the realms; and these are the halogene connectives, chlorine, iodine, bromine, and fluorine, of one class, and phosphorus, as the type of another class: the latter being chiefly found as a special connective element in the organic realms, and the former in the inorganic.

These distinctions are mainly applicable to the natural

chemistry of the realms, and need not interfere with the distinctions of artificial chemistry and metallurgy. Amphigenic elements are generally classed with non-metallic elements; although the method is more conventional than natural.

Relative Amounts of Elements.—In estimating the relative importance of the elements in nature, with regard to mass in different combinations, Professor Faraday gives the first rank to oxygen, which he computes to constitute much more than half the crust of the globe. "Oxygen," he observes, "exists most widely diffused in a solid form, in many of our most common minerals and rocks. Flint or silica contains about half its weight of oxygen; lime contains two-fifths; alumina, one-third. Oxygen exists in water as a liquid; in atmospheric air, as a gas.

"AMOUNT OF OXYGEN IN THE WORLD.

Animal	Principles	$\frac{1}{4}$	$\frac{3}{4}$
	Phosphate of lime	$\frac{3}{7}$	
	Water	$\frac{8}{9}$	
Vegetable	Principles	$\frac{1}{3}$	$\frac{4}{5}$
	Water	$\frac{8}{9}$	
Mineral	Silica	$\frac{1}{2}$	$\frac{1}{2}$
	Alumina	$\frac{1}{3}$	
	Lime	$\frac{2}{5}$	
Ocean and Waters.	Water	$\frac{8}{9}$	
Atmosphere	Atmospheric air	$\frac{1}{5}$	

"Oxygen is, then, one-half or two-thirds of the globe.

"Chlorine," he says, "though never existing naturally in an uncombined state is, when united to other elements, a large constituent both of the inorganic and organic kingdoms. It exists combined with sodium, constituting enormous beds of salt. In the ocean it exists combined not only with sodium, but also with calcium, magnesium, and potassium. It exists also in the greater number of animal liquids, and in various fluids and secretions of plants.

"Bromine is widely though sparingly diffused throughout the whole ocean, or in mineral springs; always in the state of combination. Iodine, like bromine, is extensively though sparingly distributed in sea water, sea-weeds, etc.

"Chlorine combines with oxygen in hydrochloric acid (chl. i. 0·4), chloric acid · (chl. i. 0·5), perchloric acid (chl. i. 0·7).

"Hydrogen exists largely diffused in both the inorganic and organic kingdoms. It is a constituent of various acids in combination, as the hydrochloric, hydrobromic, hydrïodic acids. It is a constituent of liquids, as water and naphtha; of certain solids, as sal-ammonia and sulphate of ammonia. In the organic kingdom it exists chiefly in the form of water and ammonia."

From this it appears that Professor Faraday considers silica, alumina, and lime, as the most abundant elements of solid matter in the crust of the globe, nitrogen the most abundant gas in air, and oxygen the most abundant element in water.

Natural Combination of the Simple Elements.—There is a natural order in the elementary constitution of the realms, which shows that chance has nothing to do with the chemical equilibrium of inorganic nature. We may show this by quoting a few eloquent passages from a lecture by Professor Faraday, on the chemical constitution of the atmosphere.

"We may ask ourselves," he observes, "what would have been the consequence so far as relates to combustion, had chlorine been the material of our atmosphere? Charcoal, so combustible now, would then have been totally incombustible; and those substances forming so large a class which are made up of carbon and hydrogen, would have only been susceptible of combustion in so far as concerns their hydrogen; the carbonaceous elements being evolved in dense fumes, as we have seen in these

experiments (made in the lecture-room of the Royal Institution). How far beyond the regions of chemistry do such phenomena as these lead us! How varied the contemplations to which they give rise! We see the whole physical economy of the universe is accurately poised, so beneficially, so admirably balanced, that not an alteration could be made without disturbing the economy of all. Then, again, consider the state in which chlorine naturally exists; and think of the greatness of omniscience which imposed that state upon it. Oxygen we have seen to constitute a large portion of our atmosphere, to be floating about untrammelled, uncombined. Had chlorine been thus permitted to waft about, how desolate would have been the world! Not an animal, not a plant could have lived. The function of life would have ceased. Even the mineral economy of the globe would have been reversed. Yet chlorine ministers to its own ends. Its compounds are amongst the most necessary to vitality: itself is useful in a thousand applications. Ever beneficent in His regulations, the Creator has locked up this element in magazines of rock salt. There its destructive agencies are subdued; yet it can readily be called forth in its uncombined state by the ingenuity of man, and made subservient to his wants."

Realmic Alliances.—The elemental realm forming the substratum of all the others, is naturally subdivided into realmic alliances of matter, since elements are grouped together in different proportions and conditions in each realm. We have, then, an atmospheric alliance of elementary substances, a pluvial alliance, an oceanic alliance, a geospheric alliance, an elemental alliance, properly so-called, for metals and other elements when uncombined in any other realm; a vertebrate alliance, an articulate alliance, a molluscan alliance, a radiate alliance, a phanerogamic alliance, and a cryptogamic alliance of elementary matter.

And, besides the elements embodied in the living or stable realms, we have wandering elements resulting from the dissolution and decay of bodies in all forms. We may, therefore, contrast embodied elements with disembodied elements in two main divisions; the first forming *one* main class, and the other *three* secondary classes: the latter being composed of the excretions of waste matter from living organic bodies, the dissolving elements of dead organic bodies, and the dissolving elements of inorganic bodies.

In studying the elemental realm, it is not only necessary to know the elements in their isolated state, but also, and more especially, their different combinations in all bodies; for a knowledge of natural chemistry is not less useful than a knowledge of artificial chemistry. We need not here dilate on chemical science, which can be more fitly dealt with in special works; our only business being to show the natural laws of order in the primary distinctions of the elemental realm. The artificial decompositions of organic and inorganic bodies give us all the knowledge we can acquire of the isolated elements of matter, and this enumeration and classification of elements forms but one branch of chemical knowledge in the general investigation of the elemental realm.

We have already seen that compound molecules of matter are the individual bodies of the elemental realm, and that these are of different characters in all the epicosmic realms. A molecule of air differs from a drop of water, and the constituent or proximate elements of organic bodies differ from those of inorganic bodies. Both individuals and classes of elemental molecules must therefore run parallel with those of the realms in which they are diversely formed in chemical structure.

SYNOPTICAL TABLE OF ELEMENTAL CLASSES AND ALLIANCES.

Z. *Supernal physical forces of elements; heat, light, etc.*
Y. Ingesta and infesta of elemental realm (?)
X. Chemical and physiological elaborations of elemental units.
W. Dissolving classes of elements.
VII. VERTEBRATE alliance of elements.
·7. Articulate alliance of elements.
VI. MOLLUSCAN alliance of elements.
·6. Radiate alliance of elements.
V. PHANEROGAMIC alliance of elements.
·5. Cryptogamic alliance of elements.
IV. ELECTROMAGNETIC or metallic alliance of elements.
III. GEOSPHERIC alliance of mineralogical elements.
·2. Reliquial alliance of elements.
II. OCEANIC alliance of elements.
·1. Pluvial alliance of elements.
I. ATMOSPHERIC alliance of elements.

The main class of elements embodied in the realms may be subdivided on organic principles of method, just as the main class of other realms, in which we find three series and one articular system or hyper-series in each of the twelve orders; but we cannot find the same complete numbers in all orders. In both organic and inorganic bodies there are often several groups of molecules in one compound molecule, such as those already mentioned in the constitution of crystalised alum.

The individual bodies of each realm being complex organisms, contain many kinds of complex molecules, and each of these contains several elements, with the exception perhaps, of the metalligenic order of the elemental realm itself; and even here, absolutely pure and simple metals are only hypothetical in many cases.

CONSTITUENT ELEMENTS OF COMPLEX MOLECULES.—The constituent base of air is *nitrogen,* and the main connective *oxygen.* All other elements are deemed extraneous or accidental. Hydrogen is the chief base of a drop of sea-water, and oxygen the chief connective; but

pure water can only be obtained artificially; and as the sea is not composed of pure water, we must admit its saline elements as components of the oceanic drop. Sodium and other secondary basic elements are, then, associated with hydrogen, the main base; and chlorine, iodine, etc., as secondary connectives, are associated with oxygen, the main connective element. In ordinary complex mineral bodies there are often more basic elements than one, and also more than one connective element; and the natural method of classification recognises the main basic, or the main connective element, as the leading feature of the group to which the mineral belongs. Thus, in Beudant's *Manual of Mineralogy*, he names the leading groups of one class or alliance: "*Aluminides, siderides, manganides, chromides;*" those of another general class, "*uranides, molybdides, tantalides, tungstides, titanides, stannides;*" those of a third class, he names "*antimonides, arsenides, phosphorides;*" a fourth class contains the "*sulphurides, selenides,* and *tellurides;*" a fifth, the "*chlorides, iodides, bromides,* and *fluorides;*" a sixth general division contains the "*hydrogenides* and the *azotides* (nitrides);" a seventh, the "*carbonides;*" an eighth, the "*borides;*" a ninth, the "*silicides.*" And these are subdivided into important groups, containing numerous genera and species.

In this system of classification some of the elements which give their names to classes are deemed metallic, and others non-metallic or connective. If elements had different sexes, like animals and plants, we might suppose some to be unisexual, and others bisexual; the latter being able to stand alone as stable individualities, or to combine, chemically, either with male or female elements; and, although the word sex is here inapplicable, there can be no doubt that some inherent form or chemical affinity analogous to that of sex, exists in all the

simple elements. It is not, therefore, a metallic or non-metallic element that gives the name to a mineral type of any kind or class, but the dominant, or the most characteristic element, whether it be deemed metallic or non-metallic: male, female, or bisexual, in chemical affinity.

The primary divisions of elemental alliances are very simple in organic realms, as they run parallel with the classes: the complex elemental units of each class being the eggs and the blood of mammals, birds, reptiles, and fishes in the vertebrate realm; and like distinctions exist in the other organic realms. The complex elemental units of inorganic realms are also diversified in the four classes of each realm; and these, again, are subdivided by the same organic law of order and degrees.

The histological analysis of proximate elements, and the chemical analysis of ultimate elements, form distinct branches of elemental science which might bear the name of elementology, in contrast with geology and mineralogy.

Realmic Unity.—Passing from the main class of complex elements as already organised in the twelve realms, to the secondary classes, which are in a state of transition from the organised to the unorganised state, or from the latter to the former, we may observe that the connective classes properly so called, are not the only things to be considered in the connections of one realm with another, and with the whole epicosmic unity. These general connectives of the elemental realm may be defined as follows:

Z. Supernal Forces, etc.	H. *Genealogical origin of elements.* U. Climatic influences of elements. Ω. Habitual supplies of elements. O. Physiorganic forces of elements.
Y. Ingesta, etc.	H. *Genetic impregnata of elements.* U. Heterogeneous infesting elements. Ω. Recent supplies of free elements. O. Recuperative masses of free elements.

X. Chemical Combinations.	H. *Artificial compounds.*
	U. Inorganic combinations.
	Ω. Digestive combinations.
	O. Organic assimilations.
W. Dissolving Classes.	H. *Artificial decompositions.*
	U. Inorganic decompositions.
	Ω. Egestive waste matter.
	O. Dissolving organic bodies.

We need only observe that there are natural transitions from the organised to the disorganised state in all the organic realms; first, in the living bodies which cast out waste matter as excretions; and secondly, the final dissolution of dead bodies. Dissolving inorganic bodies form a third natural class of transitional states; and artificial isolations of all the elements, organic and inorganic, form a fourth class, or rather a repetition of the other decomposing classes.

Artificial compounds are not, perhaps, exactly similar to natural compounds, but they are counterparts of natural transitions from the uncombined to the organised states of matter. Animals and plants continually transform the uncombined elements into a combined state, by the process of nutrition and assimilation; and they also recombine them by digestive transformations, as a preparatory step towards assimilation. Inorganic combinations of free elements are also as common as artificial combinations.

The other two kinds of general connectives are not, perhaps, so easily defined. The genealogical origin of epicosmic complex elements is manifest in the eggs and seeds of living bodies; but that of ultimate elements is a problem beyond the reach of science, in our day. Climatic influences, or the influence of the sun and stars on ovulation, is manifest in many ways; but not so obvious in the epicosmic elements of our globe, which give rise to cosmogenic speculations, such as those of Oken and Laplace. This is also a problem beyond the reach of

present knowledge. The habitual supplies of elements from surrounding space, if any such occur, or from falling meteorites, supposing them to be fragments of cosmic matter wandering in space, are questions for serious speculation. The physiorganic or purely physical forces of the elements, manifest in chemical affinity, cohesion, gravitation, heat, magnetism, etc., are better known in their effects, though quite unknown in principle or essence, as indestructible supersensuous forces.

We know nothing of the *genesis* of simple elements, and therefore the word *impregnation*, applied to them, is merely hypothetical, suggested by the natural laws of organic method. The question with regard to heterogeneous or *infesting* elements in discord with all normal action in the epicosmic realms, is also a theoretical hypothesis, suggested both by method and the obscure phenomena of infection of all kinds inimical to organic life. *Recent ingestions* or supplies of new elemental matter would apply to meteorites, supposing them to be of ultra-terrestrial origin. *Recuperative* masses of elements would be applicable to new supplies assimilated by our epicosmic world, supposing the earth to throw off into space certain portions of waste matter, as the human body throws off exhalations, and to receive and transform new supplies of elemental substances from ethereal space to be elaborated and assimilated in the realms, as food is received into the human body, elaborated by digestion and circulated in the blood, as new supplies for all the body; or, as a locomotive engine throws off smoke and steam, and takes in new supplies of coal and water.

Two of the great orders of connectives are mostly conjectural, but the other two are positive and natural. The three secondary classes of free elements in dissolving bodies, contrasted with the one main class of fixed elements in the twelve realms, form a natural distinction;

and these give rise to three opposite states in the natural regeneration of inorganic and organic bodies. All these phenomena belong to the natural chemistry of epicosmic realms; and artificial chemistry is merely a counterpart of these natural dissolutions and recombinations.

The elements contained in any complex region, or individual organism of the realms, belong to the special order of distinction in this realm; whilst the different zones, alliances, and classes are diversified in elemental structure and proportion, just as they are in their respective orders and alliances. We need not form a general synopsis of these connective orders and alliances, as they run in parallels with those of all the epicosmic realms.

THE UNITY OF MATTER.—Some of the ideas here suggested may seem very speculative, but we may observe that professional chemists are far from being averse to certain modes of speculation with regard to obscure chemical facts and phenomena. In *Weldon's Register* for October 1863, p. 619, we find the following account of Professor Graham's views on "*the unity of matter*."

"He proves it to be conceivable, and, in fact, by no means impossible, that all the various kinds of matter may be composed of one and the same kind of absolute molecules, . . . but in different conditions of motion; and this oneness or unity is in perfect keeping with the fact that some forces, such as gravity, act uniformly on all bodies.

"He finds that when a gas is allowed to pass through a minute aperture in a thin plate, such as a hole in a piece of thin platinum foil, the rapidity of its passage is entirely regulated by its specific gravity, being in fact, inversely as the square root of the density. Thus, if the velocity with which oxygen flows through an aperture be taken as 1, that of hydrogen will be 4, or the square root of 16, oxygen being sixteen times heavier than hydrogen (bulk for bulk).

"Mr. Graham conceives one kind of substance only to exist, which may be termed *ponderable matter*; and that this is constituted of ultimate atoms which are uniform in size and in weight. If these atoms were free from any motion, then the matter composed of them would be always absolutely uniform; but they always possess more or less motion, due to some primordial impulse. This motion causing their greater separation from one another, gives rise to *volume* or *bulk*, and the various different stages of aggregation: the more rapid the motion, the greater being the bulk. Matter of different molecular velocities forms the different substances which are usually regarded as *distinct elements*."

In the same number of the *Register*, p. 620, it is said that in certain experiments—"It was found that the same elementary substance may have two or three different spectra depending on temperature. . . . Nitrogen has two spectra of the first class and one spectrum of the second class. The final conclusion therefore is, that sulphur has two and nitrogen three different allotropic states.

"From spectral analysis, it would appear that sulphur and nitrogen may be decomposed."

These speculations suppose that all simple elements are complex bodies, and the heavier they are, the more complex in their atomic structure. If this be true, there may be just as much difference between the most complex and the least complex atomic inorganic element, as there is between the most complex organic individual animal and the simplest type of the same realm; such, for instance, as the human body and the lowest type of fish. The same again, as between the most highly organised plant and the most simple organic cell.

THE PHYSICAL CHARACTERISTICS OF ELEMENTS.—These are just as easily observed as those of organic bodies, and may be noticed here for the sake of method.

The typical forms of complex elemental units are those of eggs and seeds, blood and sap, in the organic realms; crystals and molecules of crystalline structure in metallic bodies; besides which many elements may assume either a gaseous, a liquid, or a solid state, with corresponding adaptations of natural form. The *radiatory modes of action* in elementary bodies, such as gold or silver, hydrogen and oxygen, are manifest in colour, transparency, specific gravity, electro-magnetism, and other properties. *Vibratory modes of action* are seen in motion of all kinds, elasticity, sonority, etc. *Permutations of state* are seen in the transitions from solid to liquid, and from liquid to gaseous changes; as well as in the allotropic states of sulphur, carbon, oxygen, and other simple elements. *Complexity of structure* is evident in eggs and seeds, though not so manifest in elementary bodies; but spectrum analysis and theoretical speculation have already suggested to chemists the probability of atomic complexity in what have hitherto been deemed simple elements. The differences of *chemical affinity* and positive or negative electricity, suggest to the mind a property in simple element, analogous to that of sex in all organic bodies; and as some have double affinities, acting either as metals or as metalloïds, we may suppose them to be amphigenic, as some of the lowest types of animals and plants are bisexual, if not hermaphrodite. Oxygen seems to be the most distinct type of a non-metallic element; alkaline metals the simplest types of the purely metallic elements; arsenic, osmium, hydrogen, nitrogen, and other amphigenic elements, the types of metalloïds; and as these peculiarities seem to correspond to the organic differences of sex, *male*, *female*, and *bisexual*, all elements may be distinguished from each other by different chemical sexes and affinities: the non-metallic elements being male or *oxygenic*, the metals being female or *metalligenic;* the metalloïds, bi-

sexual or *amphigenic.* In eggs and seeds the male and female elements are necessarily united.

Inorganic and organic bodies are, no doubt, very different; and although physical and physiological characteristics may be similar and parallel in many points, they are still very different in others, and far from being identical. It is not from identity of structure, therefore, we compare the chemical affinities of elements with those of natural attractions between male and female organisms, but merely with regard to the unity of an organic law, efficient in all realms, both inorganic and organic.

The *chemical modes of action* are different in metals and in metalloïds according to their natural affinities, whatever be the structural cause of difference in these affinities. The properties of inorganic elements analogous to those of *alimentary constitution* and *vascular temperaments* in animals and plants, could not be analysed without a definite knowledge of the atomic structure of elements themselves, now deemed simple, although conjectured by Professor Graham, to be complex in proportion to their known specific gravity. We need not hazard any theory on this point, then, when all we know is, that we are entirely ignorant.

The elemental realm is definite in its distinctions of complex elemental units, proximate elements, and ultimate elements. The physiological characteristics are also definite in each of these degrees of analytical distinction. The classes and alliances of complex elemental units in parallel with all the realms, are also definite and positive. Elementology, therefore, is a complete branch of epicosmic science: and if ultimate elements could be further decomposed, the knowledge thus acquired would not belong to epicosmic elementology, as here defined, but to cosmic and intercosmic ethereology: a much more subtile view of matter than that of epicosmic elements.

CONCLUSION.

Having analysed the realms, and given a general view of our philosophy, what is the result? What have we done that differs from what had been already done before? We have given a taxionomic view of human nature and of epicosmic unity,—*taxis* (order), and *nomos* (law),—a systematic view of the natural laws of order, number, weight, and measure. Although numerous attempts have been made by zoologists and botanists to discover natural laws of order in their systematic classifications, we had no organic method. Divine order in the realms of nature is still a mystery to science in a unitary point of view; and not only are taxionomic views in a chaotic state with regard to the organic realms, but they are deemed unknowable in other realms. "Organic Philosophy" is a new term applied to universal nature. Neither "moral" nor "natural" philosophy have hitherto been taxionomic, and therefore we have shewn that nature is ruled by organic laws in every sphere of life and physical phenomena. Not to complicate the question of mere exposition, we have dwelt on numbers and divarications more than order, weight, and measure, as functions of organic method and organic science. In other volumes we shall enter into more details.

Organic numbers have had no place in individual biology nor in comparative biology, although harmonic fractions are a necessary part of all organic laws. Order and association, federation and cooperation, have had no adequate attention in the study of anatomy and physiology, histology and embryology; not to mention the more recondite fields of life and organisation, in psychology and sociology. Taxionomic biology and epicosmology differ,

then, from all the special sciences on these questions, as natural order differs from confusion.

The taxionomic view of man's physical nature shews not only that monkeys are like men in bodily conformation, but that all the lower animal and vegetable organisms are constructed on the same plan of order and arrangement. An epicosmic universe, a collective realm, and an individual organism, are constructed on one principle of unity. All the classes of a realm own one general type; all the alliances of one class, and all the families of one alliance, are affiliated in their leading forms and features. The insect and the worm, the vegetable and the mineral, are made like man; the inorganic realms are built on the same principles of order; one law rules the world of life and organisation, from the simplest inorganic bodies to the highest animal; and man is in community of structure, not with apes alone, but with all the realms of nature. The creation claims affiliation with the Creator, and man may claim affiliation with all the creatures of the universe.

In speaking of the human body as a type of unity, we have given a taxionomic outline of anatomy alone; and this is not sufficient for our purpose. We must give a similar view of physiology; for that is even more important, as a basis of medical art and science, than static taxionomy as a basis of other natural sciences. Synthetic views of human nature and of universal nature are thus rendered simple and consistent in every sphere of science, and the human mind can understand the laws of the Creator as revealed in the creation.

Psychology is ruled by the same laws as physiology and sociology. These three sciences will form the subjects of succeeding volumes, in which we shall endeavour to shew that one organic law rules all worlds, and that the human body is a type of all creation. The natural

corollary of this doctrine is that taxionomic anatomy and physiology will henceforth become a necessary part of education for all classes.

But why do we object to Comte's "Positive Philosophy" and Darwin's theory of "the Origin of Species by Natural Selection,"since we admit that nature is subject to immutable laws, and that metamorphic evolution is manifest in all the known phenomena of embryogenesis and sociogenesis? We object to Comte's philosophy because it ignores God in nature and in spiritual revelation. We object to Darwin's theory because it ignores all the evidences of design in the creation, and rests on the basis of "physical causation" or "incidental secondary causes." Nothing is known of either cosmogenesis, epicosmogenesis, or realmogenesis. The nebular theory of cosmogenesis is a physical speculation; the Darwinian theory of realmogenesis is not irrational, though doubtful; and as nobody has put forth a theory of epicosmogenesis, we might just as easily suppose that all the realms are evolved from each other in succession,—the atmosphere being first evolved from nebular gas, the ocean from the atmosphere, the land from the ocean, the cryptogamic realm from the inorganic realms, phanerogamia from cryptogams, polypes from plants, worms from polypes, molluscs from radiata, insects from worms, and vertebrata from articulata. Thus Darwin's theory of evolution may include epicosmogenesis as well as realmogenesis and the origin of species.

The nebular theory of cosmogenesis implies that all cosmic and epicosmic forces are derived from the nebulous matter supposed to give origin to solar systems by rotatory motion, as explained in Laplace's system of "celestial mechanics." When the first Napoleon asked Laplace why he had not mentioned God in his theory, the philosopher is said to have replied that he had no need of that hypothesis; and this reply is deemed ex-

ceedingly witty by physical philosophers. May we ask if they believe that anything can come from nothing? or that mind is merely one form of physical force derived from other forms of physical force, such as matter, heat, and motion? It would be just as easy to suppose that all the motions of the human body may be explained on the hypothesis of physical and mechanical principles alone, without the hypothesis of a living soul, to think and direct all the general movements of the organism. We know that heat exists in the body, and that all the motions of the organs are governed by the laws of mechanics; what need is there, then, of the superfluous hypothesis of a living soul which nobody can either see or understand? Such views of "physical causation" are evidently superficial. We know that the human body is formed in the womb, without conscious intellection on the part of the fœtus; but not without an automatic action of the soul, which is equally automatic and unconscious throughout life. Consciousness is not the only mode of action in the soul, then; nor the only manifestation of organic force.

Is it not more rational to believe that every kind of force exists eternally, and that nothing is created but new forms and evolutions of force by the Creator? On this hypothesis, the infinite is everlasting and unchangeable: the finite alone being mutable in form and organisation. Spiritual force is eternal; mental force, eternal; instinctual force, eternal; physiorganic force, eternal; and none of these can be evolved from each other, although they coexist and may be manifested simultaneously or successively, in the finite limitations of time, space, and motion.

It does not shock our reason to suppose that natural phenomena are governed by eternal laws, and that the evolutional laws of genesis in primary creation and in

secondary incarnation are one in principle; but we deem it irrational to suppose that any kind of genesis occurs without genitors; any kind of form without motion; any kind of motion without force; any kind of force without control by law and understanding.

Intelligence and design must, in our conception, preside over all laws and forces in the evolutional and equilibrial phenomena of nature; and, although we do not know how the finite human mind was isolated *ab initio* from the absolute, we see that it is developed by the influence of the Divine mind, teaching us by revelations of eternal truth in nature and in Scripture. We learn the laws of God by studying them in His works and in His Word, and these laws give the form of truth to the human mind; which truth is the eternal form of God's own mind. And hence it is that we understand in what sense God created man in His own image.

In speaking of the isolation of the human mind as a finite individuality of forces, we do not speak of absolute isolation, which we deem impossible. The human mind can no more be isolated from the absolute, than the forces of the human heart can be isolated from those of the whole body. All definitions of individuality and finite units are therefore relative; the meaning of the word absolute itself, in fact, is necessarily limited in its relations to the finite. All inorganic realms are in connection with the physical forces of universal nature; all living creatures are in close relation with the automatic forces of the universe; all human intellect is in close relation with Divine intelligence, converting and controlling every other kind of force in the creation.

From this point of view, man's true place in nature will be manifest: his *place*, and *faith*, and *life*, as a religious subcreative being, in cooperation with his Maker; not as a mere animal, unconscious of a higher use than

that of satisfying physical propensities; but living and labouring consciously for purposes of *industrial uses, artistic beauty, scientific truth, social* and *religious goodness*, in collective organisation and cooperation. Religion is not a matter of indifference to science then, nor science to religion.

Although Christian churches may claim higher wisdom for religious revelation than human science can attain to, it does not follow that the clergy have a deeper insight into either natural or spiritual truth than laymen, who are better educated in the natural and abstract sciences.

The Church of England does not pretend to be infallible; but it claims the right to declare what doctrines shall be taught within its pale, and to exclude the teaching of all unauthorised creeds, be they true or not. This authority of definition and limitation may be made compatible with every advance of knowledge, where the clergy are sufficiently enlightened to keep pace with the progress of true knowledge, in both natural and spiritual revelation.

Ecclesiastical authorities should bear in mind, however, while they claim the right of defining and limiting the doctrines to be taught in the church at any given time, that revelations are only transitorily sufficient standards of moral truths, not being absolute, inasmuch as they partially or completely supersede each other in successive ages of the world. Patriarchal and Mosaic polygamy have been abolished by Christian monogamy; Mahomedan polygamy, Brahminical castes, and Buddhist vegetarianism are not supposed to be either universal or eternal religious institutions on this globe, although their devotees may claim divine wisdom for the authority which gave them to the world. The religions of ancient Egypt, Greece, and Rome are now extinct; and other religions now extant are not unlikely to be superseded by Christi-

anity. The wisdom, which is well adapted to the physical and moral government of infants, is not suited to the physical and moral wants of adult life; and the same may be said of the revealed religions adapted to different races of mankind, in different climates of the earth, and in successive ages.

The love and wisdom of Divine Providence have to deal with human ignorance and errors, passions and excesses, as well as with the absolute forms of goodness and truth, in giving revelations and religious dispensations to the world; and those who measure traditional forms of history and doctrine by abstract mathematics, show their lack of wisdom in appreciating the progressive evolutions of moral and religious understanding in this natural life.

Mathematical and logical minds, with little spiritual penetration or intuitive comprehension, find verbal inaccuracy and discrepancy in scriptural traditions, for which believers claim divine authority. Controversial quibbles thus arise, unsettling points of faith where no such standard as that of absolute perfection in mutable forms of expression should be claimed on either side. The dangers of sin and disease in soul and body may be contrasted with the happiness of peace and health in many ways; and these are the main objects of all revelation.

Religious revelations, without being absolutely perfect in verbal form, are sufficient for the time and circumstances of humanity in every case; but spiritual food for ignorant races of men may be just as different in form and adaptation as physical food for infants and adults in different climates; and all such adaptations accord with the wisdom of necessity, although imperfection is not perfection, nor relative goodness absolute in revelation or in nature.

The vicissitudes of language alone are sufficient to pervert the sense of verbal inspiration as one nationality

succeeds another in the same regions of the earth; and hence arise obscurities of translation and interpretation which the learned are the first to aggravate by controversial commentaries. This has been recently exemplified in the so-called "Oxford declaration", where it is deemed of great importance to assert that "the undersigned presbyters and deacons in holy orders of the Church of England and Ireland, in common with the whole Catholic Church,". . . teach in the words of our blessed Lord, that the "punishment of the 'cursed' equally with the 'life' of the 'righteous' is everlasting." No doubt of it. But what then? Who shall define the finite meaning of the word "everlasting" in the text?

We can easily understand that hospitals for the diseased are permanent institutions of civilised society, but not that the same patients are permanently detained in them, even where diseases are incurable in this natural life; but then, we know there is an end of bodily disease at death and the translation of the soul to another life. We can easily understand that God has ample means of curing moral diseases in another world, and although the necessary disciplines may be very painful, it is not accordant with common sense that they should last for ever without curing the patient; and where moral sin-diseases are incurable during one everlasting career of spiritual life, it does not follow that no translations put an end to spiritual states, as they manifestly put an end to natural states.

The word everlasting may have many definite meanings in application to natural and spiritual institutions, and the perfect cycles of individual existence in either world; but various interpretations assume the responsibility of settling doubtful questions where common sense is quite unable to determine what may be the finite sense of the original word of inspiration. Happily, these controverted points are not of vital importance to faith in revelation;

and the Church of England does not claim infallibility for the "Oxford declaration."

It should ever be remembered, in dealing with the Word of God and with His works, that individualised nature is finite and mutable; verbal inspirations are finite and progressive. Eternal laws are no doubt perfect, but these are imperfectly realised in finite creations and verbal inspirations. Imperfect man could not understand perfection: it could not be revealed to him in its integrality. The finite cannot comprehend the infinite.

Without expecting absolute perfection in nature or in revelation, enough is known already of religious truth for ignorant and learned, rich and poor, to learn alike that duty is a human call; and riches more than health, learning more than ignorance, strength more than weakness, imply responsibility as social powers for a religious use. It is quite time, therefore, that man's true place in nature should be known as clearly as his place amongst the animals, that he may not claim affiliation with the monkeys without knowing that he ought to be a man.

And now we may invite the same impartial criticism we have bestowed on other systems. We cannot claim infallibility which we deny to them. Philosophers endeavouring to interpret natural laws of truth concoct imperfect theories, just as theologians striving to interpret spiritual laws of truth concoct imperfect dogmas: and as most of them are right in some things, while wrong in others, so we may be wrong in many points, while right in others. We invite impartial criticism, therefore, to neutralise the influence of erroneous views in our philosophy, as we have earnestly and freely dealt with errors and assumptions in other systems.

Reading the work in print, we notice many verbal defects, and some mistakes which should have been cor-

rected in the manuscript. The same forms of language are repeated where they might have been varied with advantage. The word *diœcious*, page 28, line, 17, is there by mistake in lieu of the word *bisexual*. Hybrid names from Greek and Latin roots have been hastily formed in some cases, with a view to final correction, and forgotten. This occurs in the chapter on "Rodents," and in some other places. There are, no doubt, many other defects, but the general laws of order and arrangement, we believe, are accurately given, and the principles of organic philosophy undeniable. Anatomists will not object to the organic laws of order in the human body, nor deny the taxionomic views of structural economy. The epicosmic unity of realms is evidently subject to the same organic laws of number and harmonic fractions as the human body; and each collective realm is an organic unit formed on the same general plan. It is a curious fact that music is the only science in which this law has hitherto been recognised, although philosophers have always had intuitive ideas of its universal application. It is not music, however, but the human body we rely upon for proof of the organic law. It may be feared that we have imagined a procrustean form, on which we stretch all nature by an arbitrary method of parallels and fanciful analogies, where no such parallels and limitations really exist. This is a very legitimate apprehension, and should be steadily maintained. All natural laws, we may observe, however, are necessarily definite and limitative in principle and in application. The question, therefore, to be considered, is not that of orderly limitations and proportions, but that of natural as opposed to arbitrary theory; demonstrable organic unity in contrast with divergent views of natural order.

If naturalists object to our system of arrangement, on what grounds, may we ask, do they support their own?

and which one of their own very numerous and conflicting arrangements do they prefer? as they cannot all be right together. If philosophers object to our views, what proof have they of unitary truth in any other shape? Living forms and forces exist before they appear, and after they disappear; or, they do not. Yea, or nay? Is occult mental force devoid of form? can it come from nothing and go to nothing? If living force be indestructible, what are its protean forms in visible and invisible worlds? and what are the laws which govern the mutations?

Is there a world of angels and of spirits commissioned to communicate religious truth by inspiration through the prophets? or is religious revelation the offspring of natural reason and imagination?

These questions cannot be evaded by religious men, nor can philosophers ignore them or suppress them. Men of science may restrict their inquiries within the limits of secondary causes, but religion must ascend to primary and supernal causes. Philosophy is now in want of deeper science; and science stands in need of more elaborate method and philosophy.

Organic method is necessary to complete inductive method; organic science to simplify inductive sciences; organic philosophy to supersede vague speculations.

We assume that there is but one law of order in the universe; and that all finite realms are governed by that law;—that all forces are indestructible; and that physical forces co-operate with mental forces, but are not convertible with them;—that metamorphic incarnation is not primary creation; and that physical dissolution with psychical translation is not annihilation;—that souls are created before they are incarnated; and that the human form and vital forces exist before they clothe themselves with visible matter, and after they abandon the dissolving body;—that physical forces are subordinate to mental

forces in co-operative union ; and that mental forces control physical forces in all finite realms : not by arbitrary force of will, but in obedience to eternal laws of order and necessity;—that all finite units of life and organisation are subordinate parts of higher finite units, and that the parts of all complex organic units are governed by the forces and the laws which rule the whole, whatever be the given limits of the lowest and the highest integralities in nature.

In support of these assumptions we prove that one law of order rules the structure and the functions of the human body and the epicosmic universe; and that organic law reveals a taxionomic method by which we may investigate with ease and certainty the psychological and sociological as well as the physical and physiological order of creation.

To complete our epicosmic study we have now to deal with the outlines of physiology, psychology, and sociology, after which we can explain organic method and its special modes of application.

P.S.—In a recently published part of Mr. Herbert Spencer's *System of Philosophy*, we find some elaborate arguments in favour of Mr. Darwin's theory, rejecting not only the common notions of Creative Wisdom, but denying the existence of a Creator, deemed superfluous in the universe. We need only reply to such a line of argument, that we do not suppose God ever creates anything from nothing ; nor do we suppose He ever subverts the operation of natural laws by any kind of arbitrary and irregular supernatural intervention on particular occasions. We suppose that man has power to conduct human creations in accordance with natural laws ; and that God has power to conduct His creative

operations in accordance with necessary and eternal laws.

To account for the creation, Mr. Spencer says: "We have to choose between two hypotheses—the hypothesis of special creation and the hypothesis of evolution. Either the multitudinous kinds of organisms that now exist, and the still more multitudinous kinds that have existed during past geological eras, have been, from time to time, separately made; or they have arisen by insensible steps through actions such as we see habitually going on. Both hypotheses imply a cause. The last, certainly as much as the first, recognises this cause as inscrutable. The point at issue is, how this inscrutable cause has worked in the production of living forms. This point, if it is to be decided at all, is to be decided only by examination of evidence."

Mr. Spencer examines the evidence in his own way, and proves many subordinate things to be true which nobody ever denied. We need not follow his arguments, but we have a word to say about his premises; for evidence is one thing, hypothesis another. He says "we have to choose between two hypotheses"—not with regard to the inscrutable cause, but the creative modes of action of that cause. This is an illogical substitution of one question for another: the working of one kind of force for that of all kinds of force. We must first deal with the inscrutable cause question, and then with the facts and modes of creation and evolution. How does physiorganic force work in the production of living forms? How does instinctual force work? How does mental force work? How does moral force work in the evolution and development of living forms? Mr. Spencer does not definitely ask these questions; nor does he examine all the evidences of the united action of all these forces in the world.

There are two antagonist hypotheses with regard to the principiant cause of living forms in nature: one hypothesis supposes infinite mind to be the guiding force of all creation; the other supposes physical force in matter to be supreme. All such one-sided hypotheses as these are inadmissible, because the one excludes mind, as a supernal force; the other excludes matter, as an eternal force in nature. We suppose all kinds of force to be indestructibly coexistent; and mind to have supreme control, in accordance with eternal laws. "The point at issue," then, is not "how this inscrutable cause (unwarrantably supposed to be only physical) has worked in the production of living forms"; but whether or not mind controls matter in the process of causation. We assume that the Divine mind controls all matter and creates all living forms; Mr. Spencer assumes that there is no proof of the existence of supernal and creative mind; that physical forces are sufficient to account for all the evolutional phenomena of creation. In either case embryonic evolution and organic development are subordinate questions, strictly within the limits of observation and scientific analysis. Nobody denies the facts of evolution within these limits, although many people doubt the speculative inferences of Mr. Darwin and his disciples.

The idea of force as a principiant cause necessarily precedes that of motion in the human mind; both force and motion precede evolution and development, on whatever scale we may imagine these to occur, in time and space.

The real question to be dealt with in the controversy is that of the convertibility or the inconvertibility of forces of all kinds, physical and metaphysical, and the necessary coexistence of all known kinds of force, as supernal causes of evolution in the universe—physiorganic, instinctual, mental, and moral forces; not necessarily

perhaps, independent kinds of supernal force, but different aspects in the modes of manifestation of one infinite supernal force. Nobody denies that indestructible principiant forces are the only *true causes* of motion, evolution, and development. Are the automatic and the autocratic modes of manifestation ruled by one law of organic operation and perennial equilibrium in universal nature ?

Every enlightened mind admits the indestructibility of forces, and that force of some kind or kinds is the cause of evolution. Has mental force or *design*, anything to do with causation ? or is physical force by *chance* the only deity controlling laws of evolution ? That is the philosophical question to be mooted first. We may concede to the evolutionist philosophers all they ask for, in thè domain of facts, and still maintain that the admission makes no difference whatever to the previous question of causation. The uniformity and universality of natural laws of order in the universe are quite as earnestly admitted and investigated by creationists as by evolutionists.

The contrast between the two is this :—evolutionists suppose that inscrutable and undefined force "has worked in the production of living forms"; creationists suppose that definite mental, moral, instinctual, and physiorganic supernal forces cooperate in the production of living forms. We must examine the evidence, then, of the working of all these kinds of supernal forces or causes in nature, not of one kind alone, or one undefined aspect of their united operations.

The law of evolution as observed in the development of a living organism from a simple germ and its surroundings may be just as easily conceived to rule the development of a globe, a solar system, or an immeasurable universe of systems, from simple germs and diffused elemental matter into complex organisms; but no amount of

time and space occupied in the process of evolution and development can exclude the question of causation, or the question of creative forces, physical and metaphysical, in the operation. Special evolutions and developments are necessarily limited in time and space; principiant forces are eternal and infinite. Evolutions are embodiments of forces; but forces are the causes of embodiments. What is the nature, then, of these "inscrutable causes"? Is it physical alone or hyperphysical? Intelligent or unintelligent? Or shall we postulate that mind is a supernal force as well as matter; and that all forces are necessarily controlled by law and understanding? This is our hypothesis.

From this point of view, both physical and metaphysical forces are involved in all the finite evolutions and developments of epicosmic realms, cosmic and hypercosmic nature. Besides the evidence of a physiorganic universality of causes, we have to look for the evidence of an instinctual, a mental, a moral universality; not independent of each other; but one universality of principiant forces, with four main degrees of depth in analytical distinctions. We must not let the words "inscrutable cause" mislead us into the illogical position of analysing structural, physiological, psychological, and sociological evolutions in finite nature, without looking for a parallel order of creative forces as the true causes of all physical and hyperphysical phenomena.

Creationists scrutinise causes as far as they can trace the working of all forces in the evolution and development of inorganic and organic forms; while evolutionists delude themselves with the negative assumption implied in the words "inscrutable" and "unknowable." Universality is not infinity; the most immeasurable complex unities of nature being as finite as the smallest complex individualities. Infinite, unknowable, inscrutable,

have an unfathomable meaning; universal, biniversal, individual, have a finite and definite meaning. For want of an organic method, evolutionists cannot trace the evidences of psychological forces in cosmic nature. Order, number, weight and measure, are merely "mathematical laws"; as if all mathematical laws were not in themselves the strongest evidence of mental force in universal nature, as well as in human nature.

The vital forces of the chick are supposed to be "*latent*" in the complex elemental substance of the egg from which they are evolved; but no physiorganic or instinctual forces are supposed to be "latent" in the elemental matter of the universe. Physical forces are evident in the matter of a watch or a steam-engine; and mental forces or design are manifest in the mechanical structure of these human creations; gravitation rules the pendulum of a clock; physical forces and gravitation rule the matter of the human body and of our solar system; but no evidence of design or mental force and function is recognised by physical causationists, in the mechanical structure of a living organism, or of a cosmic universe. Surely the words *latent* and *inscrutable* are the "hocus-pocus" of physical causationists.

As an example of the argumentation of evolutionists against the "special creation hypothesis," we may quote a few passages of Mr. Spencer. "Besides being absolutely without evidence to give it external support," he observes, "this hypothesis of special creations cannot support itself internally—cannot be framed into a coherent thought. It is one of those illegitimate symbolic conceptions so continually mistaken for legitimate symbolic conceptions, because they remain untested. Immediately an attempt is made to elaborate the idea into anything like a definite shape, it proves to be a pseudo-idea, admitting of no definite shape. Is it supposed that

a new organism, when specially created, is created of nothing? If so, there is a supposed creation of matter; and the creation is inconceivable—implies the establishment of a relation in thought between nothing and something—a relation of which one term is absent—an impossible relation."

To this argument we reply first, that no philosophic mind ever could suppose that "a new organism when specially created is created of nothing," and therefore the argument has no application. But, secondly, we may ask if mental forces are created of nothing, according to the evolutionist hypothesis? or are they merely modes of motion, manifested during physiorganic evolution and development? If so, where is evidence to be found of the convertibility of physical into mental forces? Why are not all living forms endowed with mind? How is it that plants cannot think and speak? We have already mooted this question in previous chapters.

Mr. Spencer continues: "Is it supposed that matter, of which the new organism consists, is not created for the occasion, but is taken out of its pre-existing forms, and arranged into a new form? If so, we are met by the question—how is the re-arrangement effected? Of the myriad atoms going to the composition of the new organism, all of them previously dispersed through the neighbouring air and earth, does each, suddenly disengaging itself from its combinations, rush to meet the rest, unite with them into the appropriate chemical compounds, and then fall, with certain others, into its appointed place in the aggregate of complex tissues and organs? Surely, thus to assume a *myriad supernatural* impulses, differing in their directions and amounts, given to as many different atoms, is a multiplication of mysteries rather than the solution of a mystery. For every one of these impulses, *not being the result of a force locally existing*

in some other form, implies the creation of force; and the creation of force is just as inconceivable as the creation of matter. And thus it is with all the attempted ways of representing the process."

Not so. It would be vain for any human being to attempt to represent the process of creation; but no creationist is ever likely to adopt this mode of representing it. In attempting to conceive the possible modes of special creation, he might observe the mode in which the complex elemental matter of an egg is secreted in the body of a bird, and watch the special incarnation or creation of a chick in the matter of the egg. His question then would be, is this a special incarnation of a living but invisible form already existing? or is it a special creation of a living form, by converting the physical force and matter of the egg into an organic unity of vital forces? In either case a question of organisation and convertibility of force arises, which cannot be answered satisfactorily by any known hypothesis. We may observe, however, that Mr. Spencer affirms that the organic aggregation of atoms in the process of evolution is "not the result of a force locally existing in some other form;" and that, therefore, such an organic aggregation "implies the creation of force;" but this assertion is perfectly gratuitous, as the hypothesis of incarnation, being neither new nor strange, does not imply the creation of force. His assertion is groundless, then, and inadmissible.

The idea of incarnation implies that creation belongs to an invisible sphere of action; it separates the question of embryogenesis from that of the creation of souls, and supposes that the collection of complex elemental matter, for the embodiment of invisible living forms and forces, may be just as easily effected in many other ways, as we see it daily effected by birds secreting eggs. There is no need of the absurd hypothesis of "a myriad supernatural

impulses, differing in their directions and amounts, given to as many different atoms;" although this "multiplication of mysteries, rather than the solution of a mystery," is the real hypothesis of the nebular theory of cosmogenesis, evolving solar systems from diffused elements; and, as epicosmic organisms are necessarily evolved by some process from the matter of cosmic orbs, the evolutionist hypothesis, in its crudest form, implies this very "multiplication of mysteries," so much derided by our author. And, moreover, on the evolutionist hypothesis, this globe must have been evolved from something in the beginning; and the living forms which first appeared upon its surface must have been evolved from something, either before or after the globe was formed. The question of the primitive evolution of any living form or cosmic orb is just as obscure, therefore, on one hypothesis as on the other; for both suppose a beginning of some kind to finite forms; the only real difference being, that one supposes mind to be evolved from matter, in all living forms where thought is manifest; the other supposes mind to be an eternal and indestructible force; and, though neither mind nor matter be evolved from each other, law and understanding rule creations and incarnations wherever they occur, and on whatever scale of universal, biniversal, or individual embodiment.

Creationists have several questions to moot before they can entertain the hypothesis of evolution and development. They first suppose there is an invisible world of living forms and forces, as well as a visible world of living forms and forces. They next suppose that God creates all living forms or souls in the invisible world, and gives them power to incarnate themselves in the visible forms of matter in this world. They observe the transformations of simple elemental substances into mineral bodies, by chemical combinations; the evolution of plants from

seeds, buds, and bulbils; the evolution of birds and other animals from eggs; and the evolution of locomotive engines from metals and other simple elements; and, on perceiving that no mental powers are evolved from the matter of a watch or a steam-engine, by the structural arrangement, although it may possess powers of motion and locomotion, as well as powers of converting one kind of physical force into another kind of physical force, heat into motion, motion into heat, they see no possible method of converting physical force into organic force, matter into mind; and as all force is necessarily indestructible, they infer from all experience, that mental forces pre-exist, as matter pre-exists, wherever they are found united in the evolution and development of living forms. The forces pre-exist; the forms which they assume are organised, or created, by designing mind, as the matter of a locomotive pre-exists, although the form is given by creative human mind.

Evolutionists evade all these preliminary questions by means of a subterfuge, The infinite and the absolute are unknowable, inscrutable; therefore it is in vain to search for final causes. Evolution is the only rational hypothesis. The evolution of what? Living forms. Very good; but whence come living forms, if not from living forces? There are matter, heat, and motion, in a locomotive, but no mental or instinctual endowments. The only evidence of a designing mind is in the mechanism, and that has been created or designed by a human mind. In the human body there is evidence of plan and of design, apart from the possession of a soul, which proves that mental force and functional design, must have preceded the structure of the human organism, as surely as a human mind preceded and created the mechanism of a locomotive engine: even supposing the human soul to be evolved from matter in the womb, which cannot be supposed from any known experience or evidence.

The bugbear of "final causes" has misled the evolutionists into a confusion of the finite with the infinite. All indestructible forces are principiant or creative causes, and these are limited in finite living forms. They are also of various kinds, as manifested in physical, physiorganic, instinctual, mental, and emotional phenomena. According to all experimental evidence they are inconvertible, though possibly not independent of each other. The assumption of convertibility is quite unwarranted by evidence of any kind; and therefore evolutionists are no more positive or scientific in assuming the possible convertibility of physical into mental forces, in the process of embryogenesis, than creationists in assuming the possible existence of living forms and forces in a supernatural world, and the incarnation of these vital forces in the evolution of organic beings. We have the evidence of Revelation and tradition as well as that of manifest design; while nothing but the necessary cooperation of physical forces with mental lucubrations suggests, not as is supposed by some philosophers, the possible convertibility of physical force into mental force, but the necessity of accumulating physical force in the brain before it can be expended on the physical activity and waste caused by mental stimulation of the nervous centres.

Creationists believe that there is abundant evidence of universal design, implying universality of a designing mind, in the mechanism of the universe, as much as the mechanism of a locomotive implies design in a creative and controlling human mind. Darwin's theory of "the origin of species by natural selection," leaves the question of creation exactly where it was before, as far as the origin of a few primordial germs is involved, the starting-point of future evolutions and successive variations. By admitting all that evolutions demand in the hypothesis of variation, as opposed to that of permanent transmission

of all special types of organism, we have still to inquire into the origin of the primordial germs, be they few or many, simple or complex, in their original constitution. How were they formed? by chance or by design? The evolutionists have only one legitimate hypothesis, *i. e.*, that of the supposed variability of organic types, in opposition to the supposed invariability and hereditary transmission of each species. Neither of these hypotheses throws any light on the question of original creation. The one supposes simple organic germs to be originated first by chance, and gradually developed by successive evolutions into animals and plants, such as are now living or have become extinct by geological revolutions: the other supposes every special type of organism to have been created, both in germ and in organic unity, by a designing Mind or a Creator; not by chance, but in accordance with natural laws of order. Creationists see evidences of design in the Creation. Evolutionists see no such evidence, nor have they been accused of having had any such perceptions. The question still gives rise to difference of opinion. Have mental forces and design any existence in nature, any functions in the universe? Evolutionists deny the evidence; Creationists believe there is sufficient evidence to warrant a belief in the existence of a supernatural world of forces and phenomena, as well as a world of natural forces and phenomena; that mental forces are eternal and universal as well as physical forces; and that mind rules life and organisation in both the natural and the supernatural worlds, in universal as well as in individual nature.

END OF VOL. I.

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